MACHINE DESIGN

December 1954

INTERNAL COMBUSTION ENGINES

Contents, Page 3

Choice of the Leaders — CUTLER-HAMMER MOTOR CONTROL C-H — The Mark of Better Machines

DoALL BANDSAWING MACHINES WITH AUTOMATIC POWER CUT-OFF MADE BY THE DoALL COMPANY. CUTLER-HAMMER MOTOR CONTROL FURNISHED AS STANDARD ORIGINAL EQUIPMENT.

BARNESDRIL HONING MACHINE MADE BY THE BARNES DRILL CO. CUTLER-HAMMER ELECTRONIC MOTOR CONTROL FURNISHED AS STANDARD ORIGINAL EQUIPMENT.

HARVEY CYLECTOR FULLY AUTOMATIC PLASTICS INJECTION MOLDING MACHINE MANUFACTURED BY GUY P. HARVEY & SON CORP. CUTLER-HAMMER MOTOR CONTROL IS STANDARD EQUIPMENT.

MACHINE TO STRAIGHTEN AND CUT OFF TUBING FROM COILED STOCK. MADE BY WALTER P. HILL, INC. CUTLER-HAMMER MOTOR CONTROL FURNISHED AS STANDARD ORIGINAL EQUIPMENT.

It is not surprising

Improvement in manufactured articles usually comes about through companies competing for market favor, one "leapfrogging" another. But not always. There are always a few companies that don't wait for competition to bring out something better. They leapfrog themselves and as a result their hold on the market remains unbroken, their leadership unchallenged. It is notable that such consistent leaders in the field of machine design and manufacture just as consistently use Cutler-Hammer Motor Control on the machines they build. It is notable—but not surprising. For as wide awake as these companies are, it would be the supreme inconsistency for them to go to sleep on the very component that safeguards the performance they so carefully build into their machines. They provide against any risk by turning to the *known* dependability and *unchallenged* leadership of Cutler-Hammer Motor Control in its own field. And so should you. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

DECEMBER 1954
Vol. 26—No. 12

SECOND CONFERENCE ON MECHANISMS

Contemporary Design

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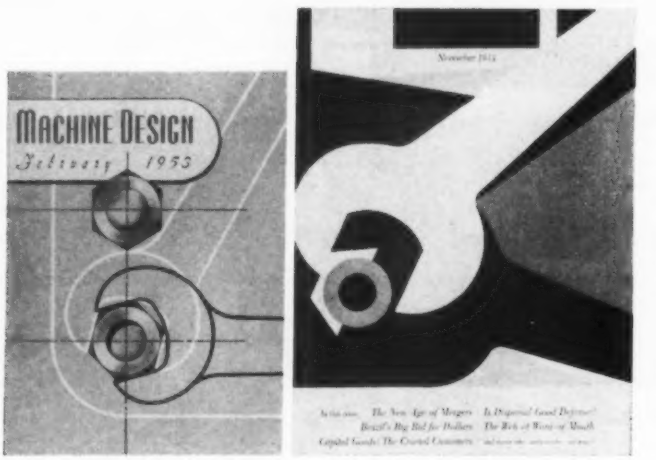


Which is Which?

Mr. John Shaw Billings
Editorial Director
Fortune Magazine
Dear Mr. Billings:

When we first saw your beautiful November 1954 cover, we did a double take. It took a few minutes for the realization to sink in that this was a souped-up version of our own February 1953 cover, a copy of which is attached.

While we admire the skill and imagination of your artist, we still prefer our own cover for our own publication.

Sincerely yours,
Colin Carmichael
Editor

Dear Mr. Carmichael:

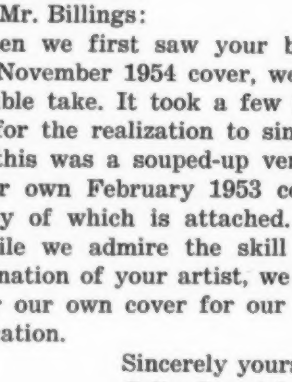
Cover artist Walter Allner, internationally known both as a designer and an honorable man, was completely flabbergasted at the sight of MACHINE DESIGN's fine February '53 cover enclosed with your letter of November 1st. It is a remarkable coincidence, and for us an embarrassing one. As a matter of fact, it was a last minute suggestion by one of our editors that shifted the position of our wrenches from a vertical angle.

Thanks ever so much for calling this to our attention in the nice way that you did.

Cordially yours,
Brooke Alexander
Assistant to the
Publisher

This Month's Cover

"Internal combustion" might describe the process an editor goes through in creating a staff article. But Keith Carlson, whose series on internal combustion engines starts on Page 156, has been muttering for weeks about those "infernal combustion engines." It's no reflection on the subject, you understand, but merely indicative of an editor's state of mind in sweating out a big job. This basic discussion of engines is epitomized by George Farnsworth's striking cover.



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Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

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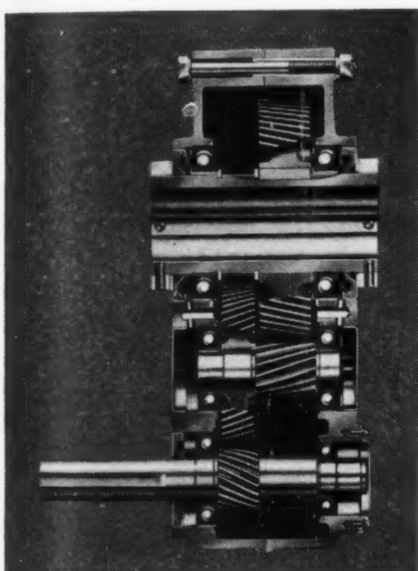
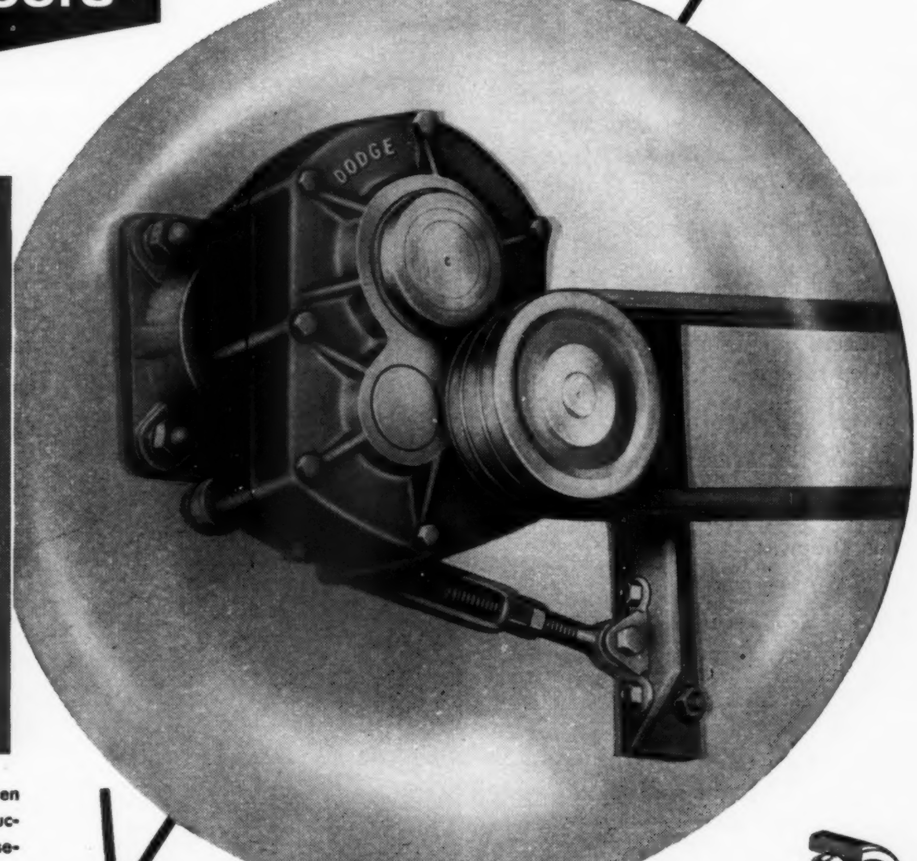
BPA NBP

Reducing Costs in Speed Reducers



New Departure **ball** bearings are used in seven basic sizes of the Dodge single and double reduction speed reducers, handling from 1 to 43 horsepower at output speeds from 12 to 330 r.p.m.



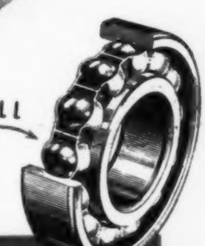
... with NEW DEPARTURES

Dodge Manufacturing Corporation's Speed Reducers make good use of design advantages offered by New Departure snap-ring **ball** bearings.

The snap rings locate the bearings in the case, eliminating the need for adjustment. Doing away with threaded or shim-type devices permits straight-through boring of the housing. Thus split-case construction is highly practical, and assembly is greatly simplified. The result is a rigid, highly efficient unit, and one in which production costs have been kept to the minimum.

Learn what New Departure can do for *your* product. Talk with your New Departure sales engineer—*today!*

NOTHING ROLLS LIKE A BALL



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Engineering News Roundup

More Pay for Draft Exempt Engineers

According to a recent report from North Carolina State College, engineers ineligible for military service received an average of $16 a month more than men subject to call for military duty. A breakdown of the average monthly salaries accepted by electrical, mechanical and industrial graduates is as follows:

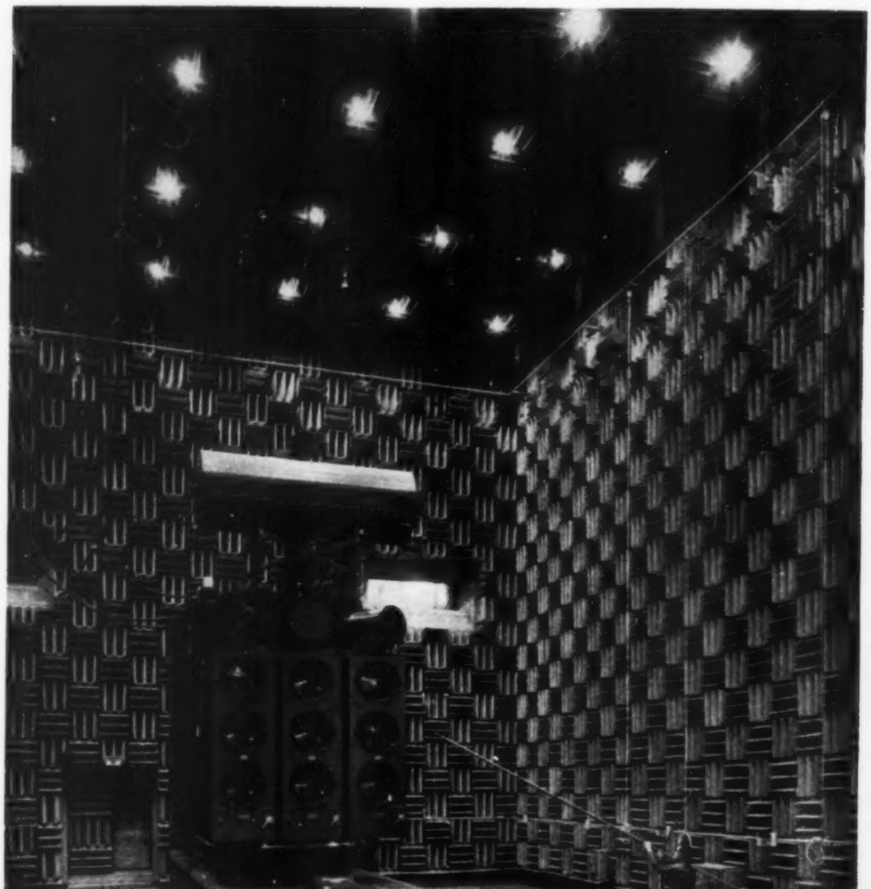
Field of Engineering	Eligible for Service	Not Eligible for Service
Electrical	$360.67	$385.36
Mechanical	340.00	372.88
Industrial	332.25	353.20

Average salary of the entire June, 1954, graduating class was reported to be $356 a month, ranging from a low of $225 a month to a high of $467. The low salary, according to Marie P. Wicker, coordinator of student affairs, went to a man who wanted to work in one particular town with little industrialization. The high salary went to a veteran with previous valuable experience in his field.

Robot Predicts Equipment Performance

Servomechanisms, valves, actuators and control instruments can be tested and their performance predicted automatically prior to actual installation.

Known as a servo analyzer, a new system was developed by Minneapolis-Honeywell Regulator Co. One control or a group of controls are automatically put through



NO ECHOS can be heard in this sound chamber, built by General Electric Co., and used to check transformer noise level. The 43-foot high room has a floor space measuring 58 by 48 feet. Sound absorption is accomplished by 5-foot thick walls consisting of 12 inches of concrete, a 2-inch layer of glass fiber, 8-inch concrete blocks, a layer of copper, a dead air space and, finally, over 12,000 glass fiber wedges

their paces by introducing rhythmic changes simulating operating conditions. Results are translated into a chart record.

Four components comprise the system. Test frequencies are supplied by a signal generator. The other three components are a portable potentiometer, control box and a recorder.

An entire test, according to the system's designers, can be completed in as little as 8 minutes. About 30 to 60 per cent of the time involved in a redesigning process can be saved, it is claimed.

Besides its previously mentioned applications, the automatic tester can be used for analog tests and in the development of airfoils and jet-engine components.

ROUNDUP FEATURE REPORT

Plastic Objects Get Bigger and Bigger

Reinforced plastic is becoming more commonly used for larger objects. Small boat hulls made of reinforced glass fiber proved so successful that larger hulls are being constructed. Plastic-bodied autos, and now plastic truck bodies, have been announced.

Weight saving is one advantage of plastic bodies for truck use. Plastic boats will not rot or become water logged.

Plastic Boats

Small plastic boats in the 9 to 16-foot range have become common in recent years. However, more recently, designers have been extending their operations to larger and larger models.

Reported to be the largest plastic pleasure yacht ever built, a 42-foot ketch of glass-fiber reinforced plastic was recently launched by Anchorage Plastics Corp. The plastic ketch displaces 10,500 pounds, but nearly half of this is in its 2½-ton lead keel. It is said to be somewhat heavier than its counterpart in wood, but more rugged and weather resistant.

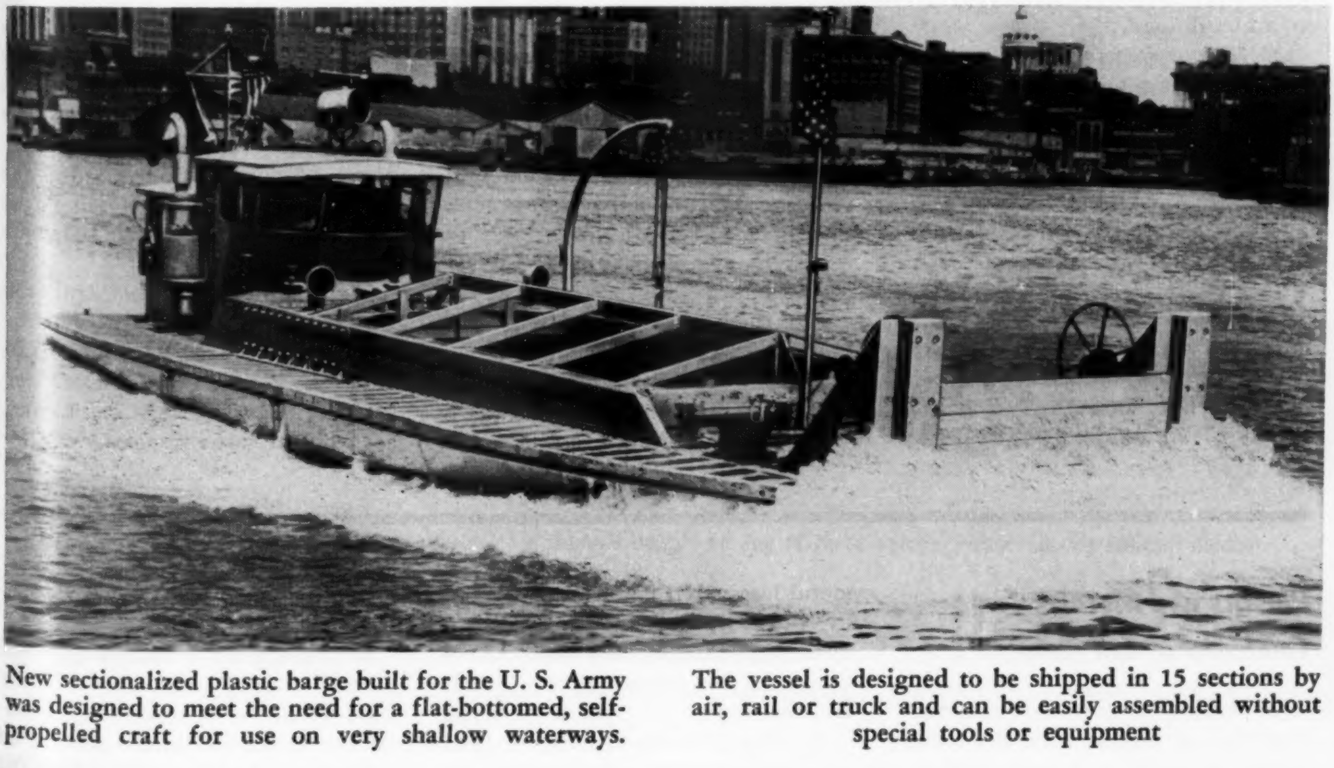
Produced by progressive laminating in a female mold, the hull provides complete permanent pigmentation, freedom from hull noises, and is completely watertight.

More recently, a larger plastic craft was built for the U. S. Army Transportation Research and Development Command. Built by Englander Co. Inc. the vessel is reported to be the world's largest plastic ship of any type.

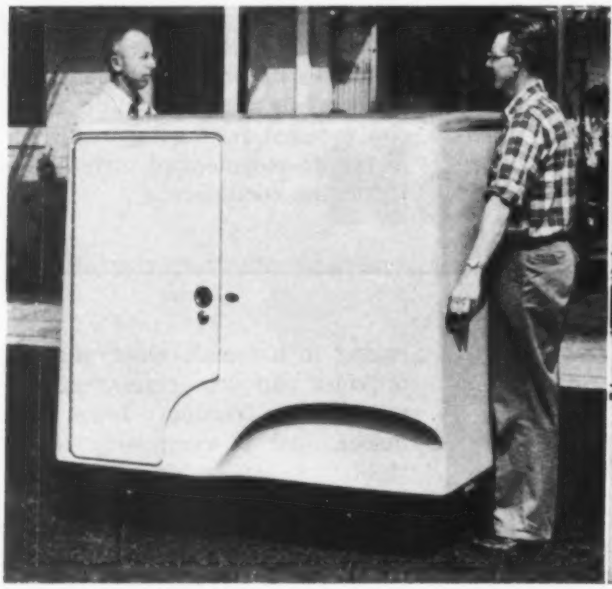
Known as a sectionalized, self-propelled barge, the vessel is 51 feet long, weighs 10.2 tons, and is designed to carry 5 tons of cargo.

Plastic honeycomb "sandwich" type construction of the hull is said to require little maintenance and provide the strength necessary for a vessel of this size.

Designed to be shipped in 15 sec-



New sectionalized plastic barge built for the U. S. Army was designed to meet the need for a flat-bottomed, self-propelled craft for use on very shallow waterways. The vessel is designed to be shipped in 15 sections by air, rail or truck and can be easily assembled without special tools or equipment



Lightweight transportable plastic truck cab, left, weighs a little over 200 pounds and is easily carried by two men. Built by Glasspar Co., it will house instruments used in oil exploration surveys. Plastic delivery truck body, right, permits increased payload because of its lighter weight. Made by Lunn Laminates Inc., the body has about the same strength-weight ratio as magnesium

tions, the boat can be transported by air, rail or truck. It can be assembled without the use of special tools or equipment. Special connectors were designed to fasten the sections together.

Powered by two 165-horsepower diesel engines, the boat has a draft of only 21 inches when fully loaded. It is designed for a speed of 7.5 mph at full load.

A 57-foot minesweeper hull is reported being built for the U. S. Navy by Defoe Shipbuilding Co. The hull will be fabricated in the same honeycomb fashion as the barge.

Plastic Truck Bodies

A package delivery truck body molded of reinforced plastics is said to be the first of its kind. Made by Lunn Laminates Inc., the body is made of reinforced glass fiber. Strength-weight ratio of glass-fiber reinforced polyester plastics in tension and compression is reported to be about equal to magnesium. Mechanically, they have high impact resistance. Chemically, the plastics resist acids and most solvents.

A portable truck cab fabricated of reinforced plastic is now being used for transporting photographic and electronic instruments used in oil exploration activities. Made by Glasspar Co., the unit is said to possess freedom from corrosion, have high impact resistance and freedom from galvanic action. These features are important to research operations in the Gulf coast and in South America for which the unit is intended. This unit weighs only 202 pounds as compared to an aluminum cab weighing 397 pounds.

Several new design features distinguish a new plastic truck trailer. Interior lining, structural beams, rear doors and door frames and an underside reflector pan are all made of a polyester resin reinforced with glass fibers.

Major feature of the trailer, made by Strick Co., is the use of reinforced plastic for structural beams instead of aluminum or steel. Because plastic has an insulating factor, the beams may be used as part of the insulation. The 6-inch plastic beams are set on 12-inch centers under a corrugated aluminum floor. Sides and roof are supported by 4-inch plastic beams. All of the plastic parts are riveted together.

Weight of the 35-foot trailer is 11,800 pounds including its refrigeration unit. Efficiency of the insulation in such that a temperature of zero F may be maintained, according to the company.

Plastics and Metal Combined in Coil Form

Combining the corrosion-resistant qualities of plastic with the formability of metal is a new vinyl-on-metal laminated material developed by U. S. Rubber and being produced by Enamelstrip Corp. Produced in coil form, the new laminate is said to be capable of being deep drawn, sheared, crimped, bent and a number of other operations without damage to the vinyl coating.

Because of its availability in coil form, it can be fed automatically into progressive dies, thus eliminating much handling. Among its potential uses are cabinets, toys and

Do these 5 NEW ASCO SOLENOID VALVES meet a special need for you?

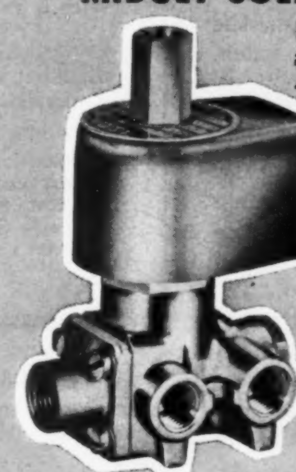
Five completely new solenoid valves were developed by ASCO during 1954. Smaller size, greater efficiency and longer reliable life fit these valves to specific industrial uses.

A NEW ASCO 2-WAY SOLENOID VALVE

COMPACT: Only 2¾" face to face; 3 13/16" overall height.

Simple: Just two operating parts. Can be mounted in any position. Low power consumption. Standard, explosion proof or watertight solenoid enclosures. Normally open or normally closed.

BULLETIN 8210A



A NEW ASCO 4-WAY MIDGET SOLENOID VALVE

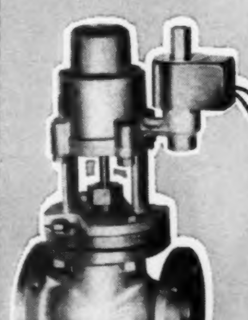
Designed for control of small double acting cylinders. Compact: Under 4½" high, 2" wide, 2" deep with standard NEMA I solenoid enclosure. Operates up to 400 cycles per minute mounted in any position. Standard, explosion proof or watertight solenoid enclosures.

BULLETIN 8345

A NEW ASCO SOLENOID PILOT CONTROL VALVE WITH SAUNDERS PATENT TYPE BODY

Absolutely tight shut-off control for corrosive liquids and gases. The dependable ASCO pilot provides automatic control of main diaphragm valve using auxiliary pressure. Available normally open or normally closed in a wide selection of body materials. Standard, explosion proof or watertight solenoid enclosures.

SPECIAL BULLETIN 8336



A NEW ASCO CORROSION RESISTANT, CYLINDER OPERATED 2-WAY VALVE

BULLETIN 8338

Two valves designed specifically for processing plants where corroding liquids or gases are handled. Many types of body materials available. Standard, explosion proof or watertight solenoid enclosures.

A NEW ASCO CORROSION RESISTANT 3-WAY SOLENOID VALVE

SPECIAL BULLETIN 8300

Write for additional details on any of these valves. Please specify bulletin number.

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WE DESIGN AND MANUFACTURE A COMPLETE LINE OF SOLENOID VALVES AND ELECTROMAGNETIC CONTROLS INCLUDING AUTOMATIC TRANSFER SWITCHES, REMOTE CONTROL SWITCHES, CONTACTORS, RELAYS, AND COMPLETE CONTROL PANELS.

industrial and commercial equipment. It is said to be applicable wherever a decorative finish and superior resistance to heat, abrasion and corrosion are required.

Electrode Is Secret Of Weld-It-Yourself Method

Said to eliminate skills normally required for good welding, new welding equipment has been designed which promises to make nearly everyone a welder. Developed by Lincoln Electric Co., the system is claimed to be a quick, easy method of repair or maintenance.

Secret of the system is a newly developed electrode and specially designed electrode holder. Starting the arc, feeding the electrode, electrode angle and the travel speed are automatically controlled. The coating of the electrode touches the work at all times so that the length of arc is automatically determined. Welding speed is controlled by the melt-off rate of the coating. A special supporting leg on the holder helps steady the electrode and control the angle.

Previews

Thrig and His Lynx

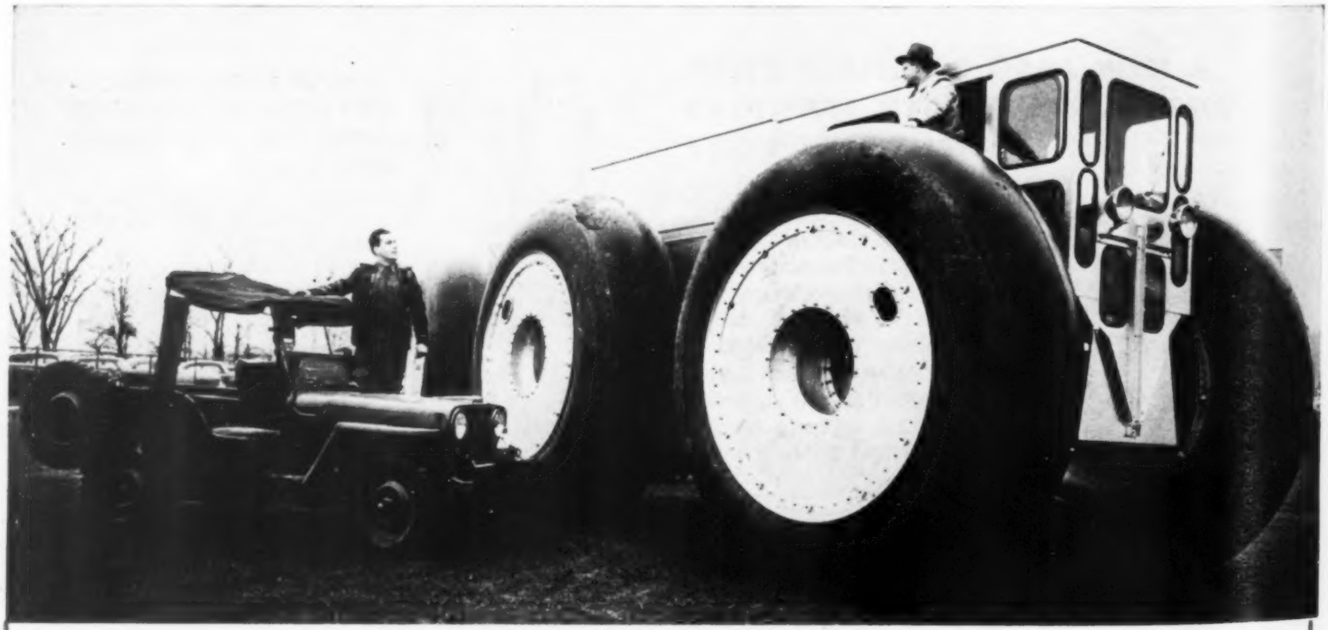
Thrig—as anyone who has read this month's Stress Relief knows—was a rather brainless character and the father of present-day mechanisms. To be fair, we must also include Thrig's lynx, since he played a major role in the development. And if you want to see how far the science of mechanisms has progressed from Thrig's day, you might turn to Page 187 for the "Transactions of the Second Conference on Mechanisms."

Caustic Questions

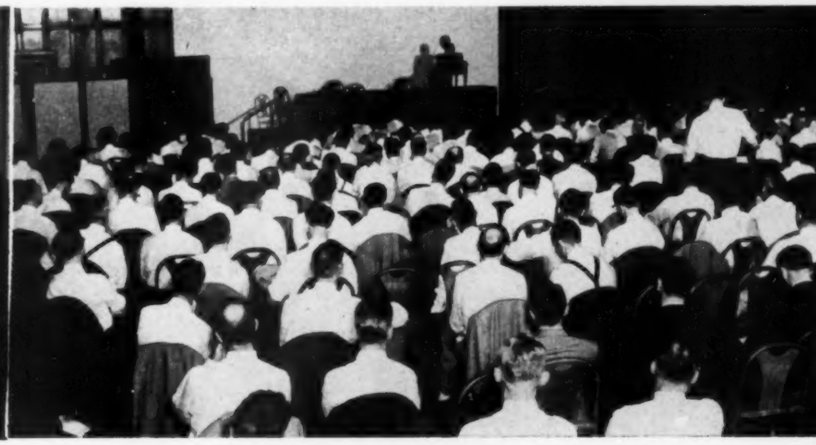
Corrosion problems often come as real caustic questions that put a designer to the acid test. (No corrosive comments, please!) Ernie Schoefer's article on Page 178 gives some excellent ideas on combatting corrosion by use of cast high-alloy (stainless) materials. High-alloy ferrous castings are the cast counterparts of wrought stainless steels, and are suitable for a similar range of difficult conditions.

Infernal Combustion

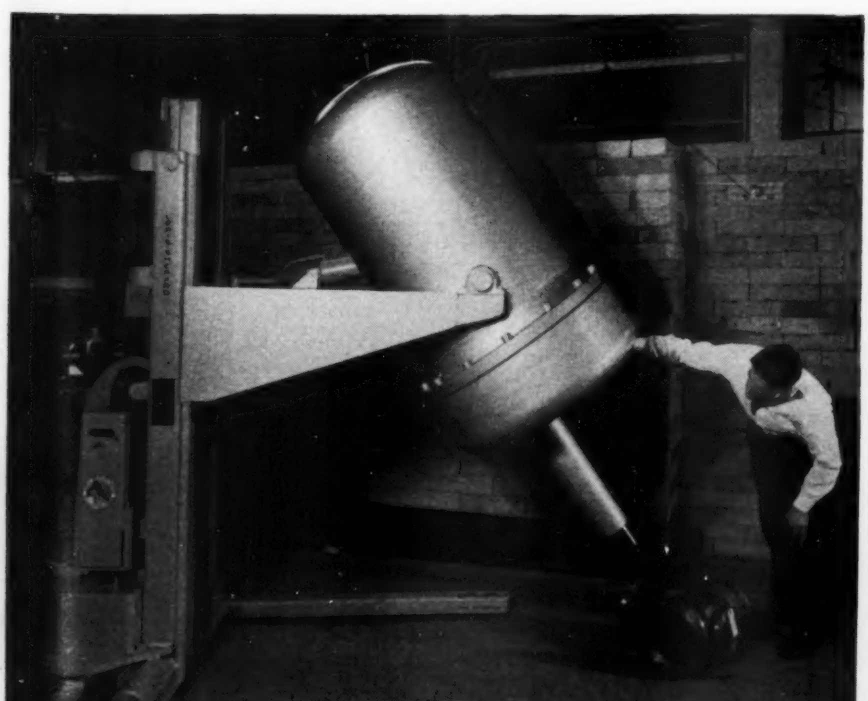
The first internal combustion engines, we recently learned, were designed about 1680—and were made to operate on gunpowder. These infernal engines have been superseded by the present internal combustion engine, which operates on more conventional fuel, although the basic principle is similar. Factors involved in gasoline engine selection are covered in Keith Carlson's article on Page 156; a later article will discuss diesel engines.



GIANT AMPHIBIOUS BUGGY which rides 6 feet about the ground is being tested for possible military service. Developed by Gulf Oil Corp., this vehicle is a recent modification of Gulf's "Marsh Buggy" which has been operating in Gulf coast swamps for 17 years. Operated by a four-wheel drive, this new version is capable of speeds up to 30 mph on land and 6 knots in water. Its 10-foot tires (120 x 33½) built by Goodyear enable it to navigate like a motor boat, climp steep banks or cross soft sand beaches. It can accommodate 20 persons and carry loads up to 4000 pounds



SECOND MECHANISMS CONFERENCE, cosponsored by Purdue University, MACHINE DESIGN and *Automation,* attracted over 250 engineers from the U. S. and Canada. Representing the three cosponsors were the men pictured at the upper left. From left to right, they are Colin Carmichael, editor, MACHINE DESIGN; Prof. A. S. Hall, Purdue University; and Roger Bolz, editor, *Automation.* Part of the group attending one of the sessions held in the Memorial Union Building on the campus is shown at the upper right. One of the speakers C. N. Neklutin, Universal Match Corp., left, discussed vibration analysis of cams



THIRD DEGREE at the rate of 1 million volts is being given this steel casting. X-rays are generated by this device, built by High Voltage Engineering Corp. Exposure time through 2-inch steel is less than 1 minute and about half an hour for 5-inch steel

Rare Metal Element Heats Precision Furnace

One of the world's rarest metals is being used as a heating element in an electric furnace. Iridium, a $175-an-ounce metal with an extremely high melting point, is the heart of a precision high-temperature furnace. Developed by General Electric, the furnace is being used to calibrate iridium and iridium alloy thermocouples at temperatures above 2800 F.

About 500 watts is required to produce these jet-engine temperatures from a 6-inch iridium coil. Ease of control and its ability to resist oxidation at high temperatures make iridium ideal for precision high temperature applications.

AGMA Index for September, 1954 decreased 1.3 per cent as compared with the August figure. The index figure for September is 135.1. AGMA index figures are computed using the 1947 to 1949 period as a base of 100.

(Continued on Page 24)

The Amerigear® patented fully crowned tooth form...

...IS THE SOURCE OF

High Misalignment Capacity

IN *Amerigear*®

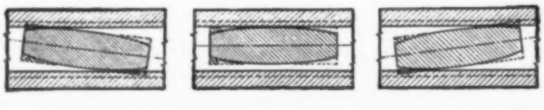
COUPLINGS

Illustrating Full Cycle Misalignment Pattern Amerigear H.M.C.*Patented Tooth Form.

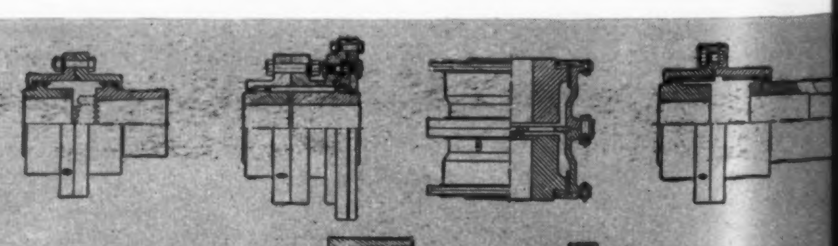
● An engineered application, using advantages of the Patented Amerigear HMC* Flexible Coupling, can solve any power transmission problem arising from:

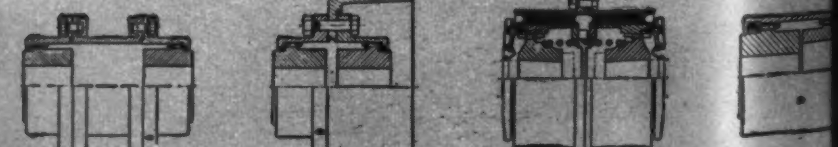
- Excessive lateral and angular misalignments;
- Tight backlash requirements;
- Space limitations;
- High speeds and loads;
- Continuous operation;

or any combination of these

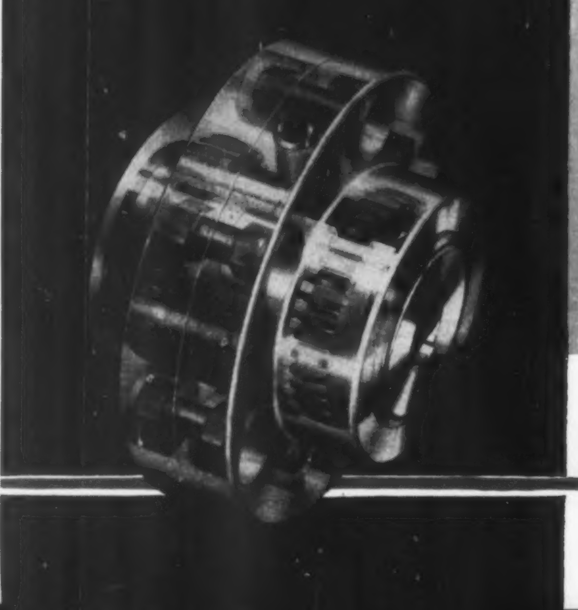


Comparison with gearing of conventional gear-type couplings shows how Patented Amerigear Tooth Form eliminates *tooth end loading* and simultaneously allows for both lateral and angular misalignment. Dotted lines indicate gear teeth of conventional gear couplings.





A few of many types of Amerigear Flexible Couplings that have been derived from Standard Type Amerigear Couplings by engineering applications to utilize the advantages of the Patented Amerigear Fully Crowned Tooth Form. Write for Catalog 501 and Bulletin 1052 which illustrate several special types, or attach coupon to business letterhead.

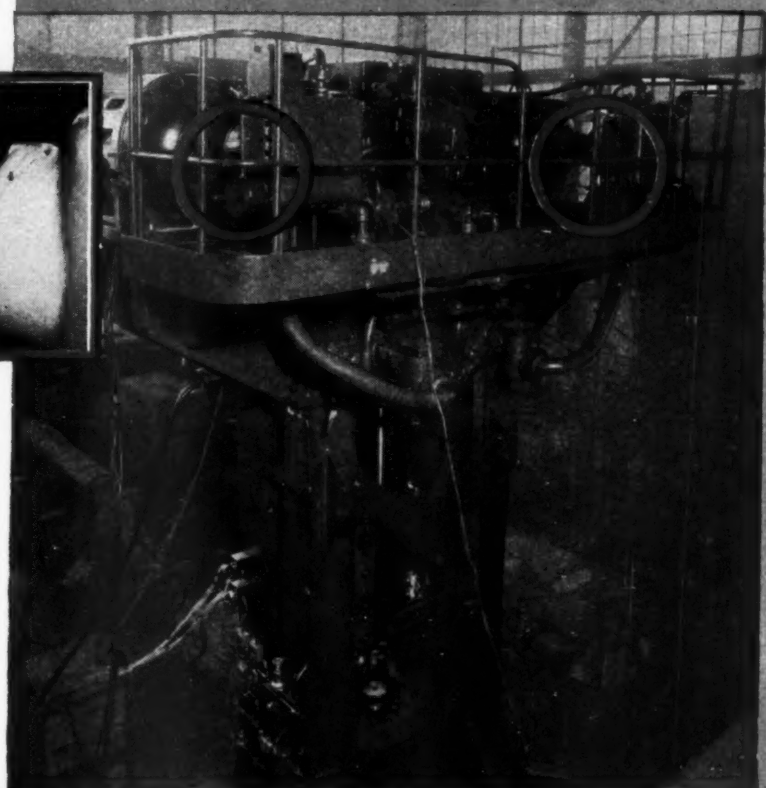


Amerigear® HMC* FLEXIBLE COUPL

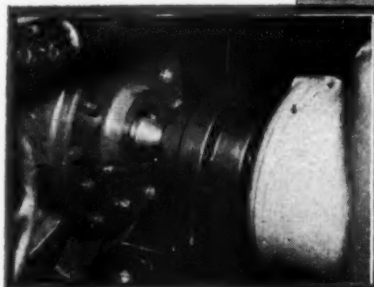
One of several standard types embodying the Pa
Amerigear Tooth Form
Patented and Patents Pending

Amerigear® HIGH MISALIGNMENT CAPACITY* COUPLINGS

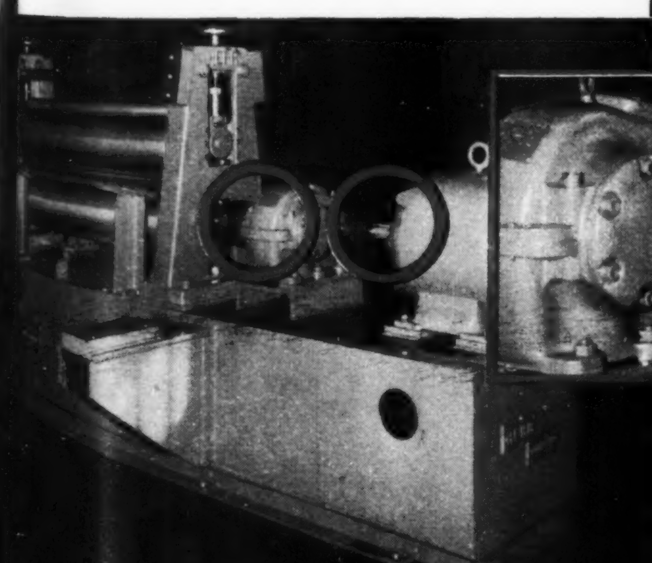
Solve power transmission problems for wide variety of metal working equipment!

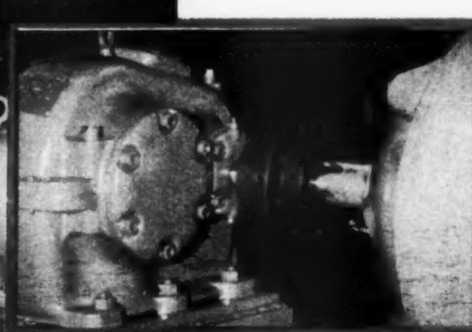


Bliss 350-Ton Capacity Hydro-Dynamic Press having dual pump and motor drive units which are equipped with Amerigear HMC* Couplings. Photo courtesy of E. W. Bliss Company, Canton, Ohio.



In this application a Standard Type of Amerigear HMC* Coupling is a vital part of the pump and motor drive units on a 350-ton capacity Bliss Hydro-Dynamic Hot Nosing Press. The pump and motor drive unit operating at 1200 r.p.m. provides hydraulic pressure to operate the press ram. Every 10 seconds the operating load transmitted increases from 125 h.p. to 150 h.p. and is held for approximately 2 seconds—thus, the load being transmitted fluctuates several times per minute. There are two pump and motor drive units on this press. This is a typical example of how a Standard Type Amerigear HMC* Coupling is utilized to solve power transmission problems arising from a fluctuating load, tight backlash requirement, space limitation, and lateral and angular misalignment conditions.





Pinch Rolls as manufactured by Herr Engineering Company on which two Standard Type Amerigear HMC* Couplings are used for the driving unit. Photo courtesy of Herr Engineering Company, Warren, Ohio.

One of several applications of Standard Type Amerigear HMC* Couplings installed on Pinch Rolls manufactured by Herr Engineering Company. In this application two Amerigear HMC* Couplings are used; one on the rotating shaft between the motor and the gear reducer, and another between the gear reducer and the roll end. Herr Engineering also use Standard Types of Amerigear HMC* Couplings for their Pay-off Reels, Take-up Reels, Slitters and other steel finishing equipment. In this application Amerigear HMC* Couplings with Patented Tooth Form are transmitting power under shock loading conditions. They minimize the effect of any lateral or angular misalignment which may occur, thereby reducing maintenance costs to an all-time low.

Copyright 1954

Amerigear Engineers are available to assist in *engineering special applications* of the Amerigear Patented Crowned Tooth Form and for adapting Amerigear Standard Type HMC* Couplings to solve your power transmission problems. Write for Catalog 501 and Bulletin 1052, or attach coupon to your business letterhead.

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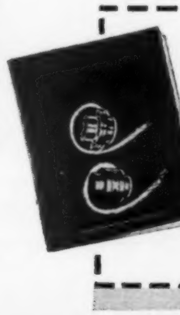


AMERICAN FLEXIBLE COUPLING CO. • Erie, Pa., U.S.A.

Please send me further information regarding AMERIGEAR COUPLINGS with the Patented Fully Crowned Tooth Form as described in Catalog No. 501 and Bulletin 1052.

Name .... *Title* ....

Company ....

Address ....

City .... *Zone* .... *State* ....

Please attach to your business letterhead.

Dept. MD 619

Engineering News Roundup

(Continued from Page 21)

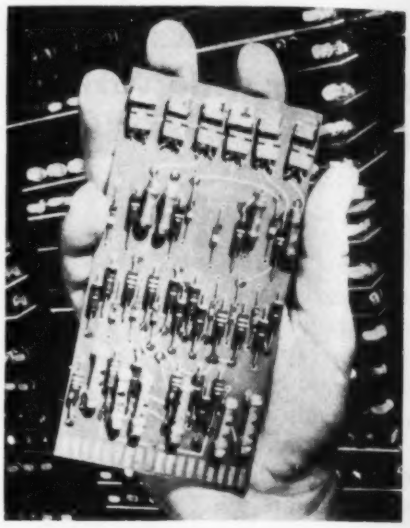
Hardly Any Power Needed for New Computer

Use of transistors in an experimental calculator have resulted in a 95 per cent decrease in power requirements. Besides this drastic power reduction, size of the unit has been reduced to one-half.

Demonstrated recently by International Business Machines Corp., the experimental unit is comparable in capacity to the company's type 604 calculator which uses 1250 vacuum tubes. This experimental engineering model is said to be the first fully operative transistorized computer complete with automatic input and output.

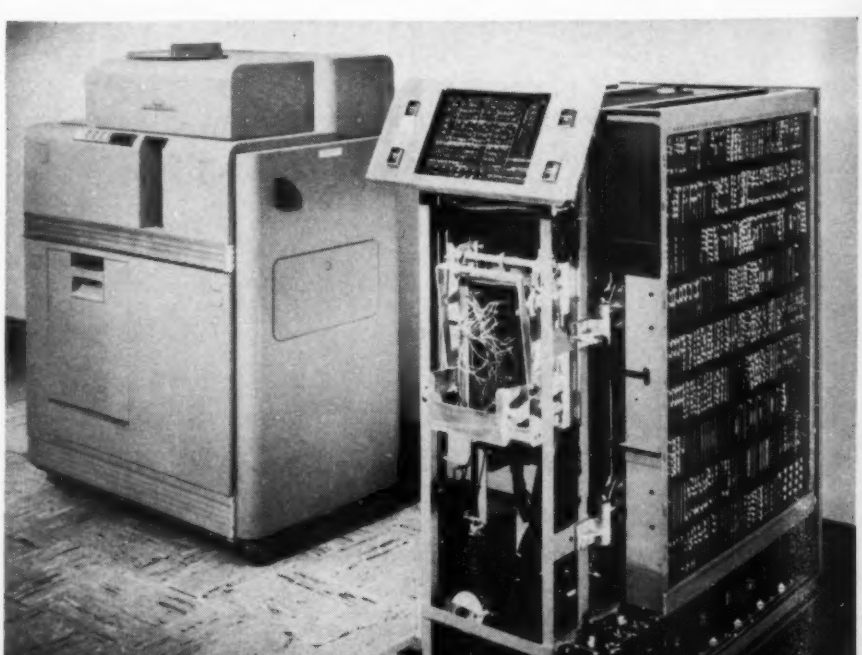
More than 2200 transistors are used in the machine. A number of these, according to IBM, were developed by the company's own engineers to meet the operating characteristics required in computer circuits.

Miniaturization of the computer components is facilitated by the use of printed circuit wiring panels. Each of the 595 printed panels is about the size of a two-cent postcard.

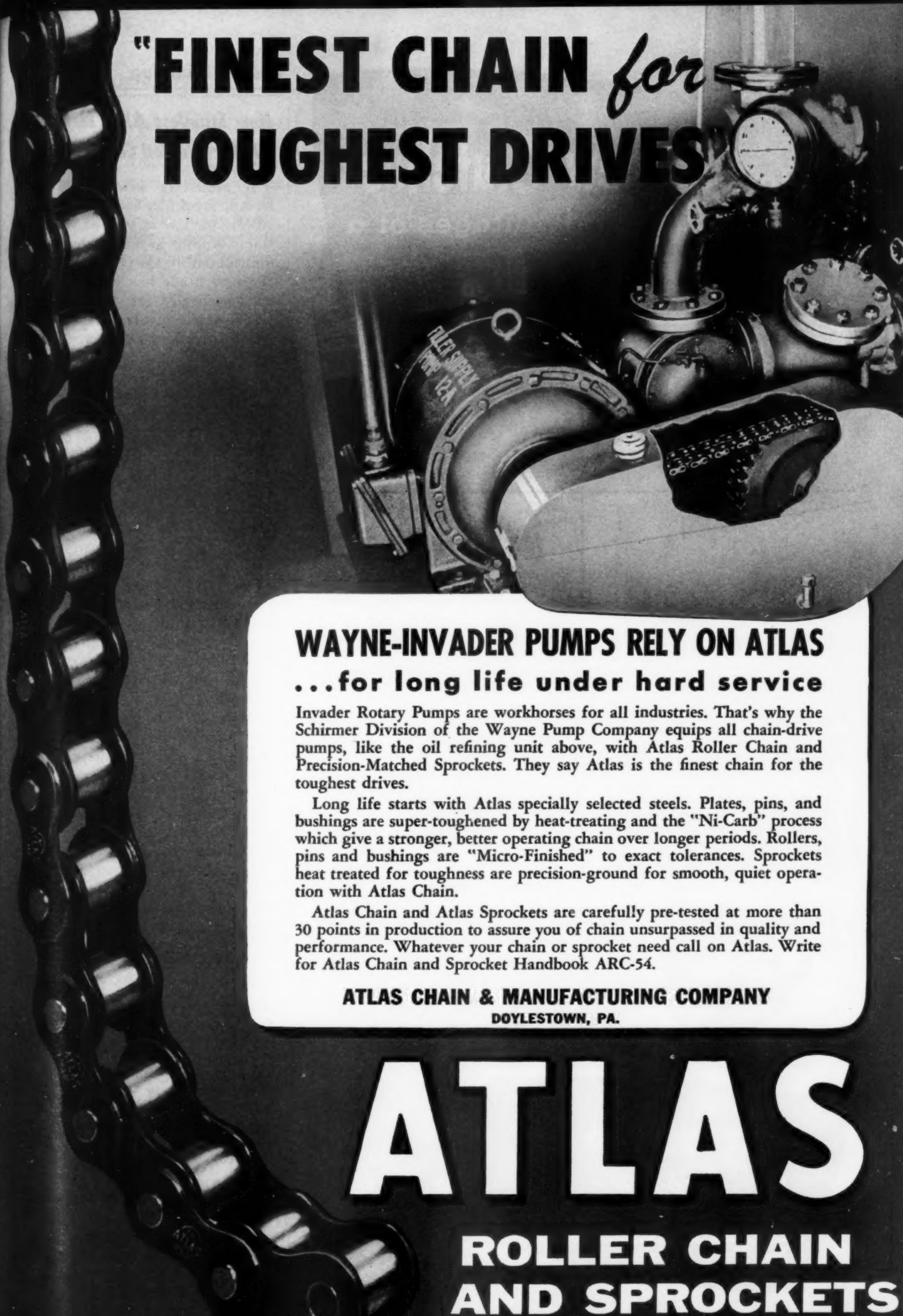


One of the 595 printed circuit panels used in the new IBM all transistor computer. Six transistors are mounted at the top

Production and maintenance requirements are expected to be reduced due to the use of printed wiring. Another factor contributing to reduced maintenance is the long transistor life as compared to vacuum tubes.



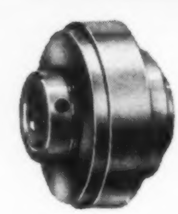
New IBM transistorized computer, right, is one-half the size of its vacuum tube operated counterpart. High-speed punching unit is shown at the left

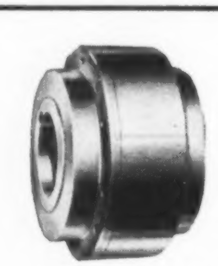

"FINEST CHAIN for TOUGHEST DRIVES"
FILLER SUPPLY PUMP 12A
WAYNE-INVADER PUMPS RELY ON ATLAS
...for long life under hard service
Invader Rotary Pumps are workhorses for all industries. That's why the Schirmer Division of the Wayne Pump Company equips all chain-drive pumps, like the oil refining unit above, with Atlas Roller Chain and Precision-Matched Sprockets. They say Atlas is the finest chain for the toughest drives.
Long life starts with Atlas specially selected steels. Plates, pins, and bushings are super-toughened by heat-treating and the "Ni-Carb" process which give a stronger, better operating chain over longer periods. Rollers, pins and bushings are "Micro-Finished" to exact tolerances. Sprockets heat treated for toughness are precision-ground for smooth, quiet operation with Atlas Chain.
Atlas Chain and Atlas Sprockets are carefully pre-tested at more than 30 points in production to assure you of chain unsurpassed in quality and performance. Whatever your chain or sprocket need call on Atlas. Write for Atlas Chain and Sprocket Handbook ARC-54.
ATLAS CHAIN & MANUFACTURING COMPANY
DOYLESTOWN, PA.
ATLAS
ROLLER CHAIN
AND SPROCKETS

How **3 New Clutches** give you the advantages of a full complement of sprags...

NEW **SMALL CLUTCHES**

To meet industry's demand for small size clutches of high torque capacity, low price, long life, and minimum maintenance.



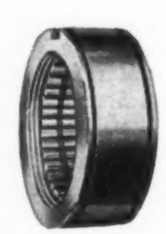


NEW **LARGE-BORE CLUTCHES**

For backstop applications requiring large-bore sizes. Four models: with maximum bores of 6", 8", 10", 12". Intermediate sizes also available.

NEW **SERIES 50 CLUTCHES**

Designed for applications where customer can supply his own inner race when adequate concentricity is already provided. Particularly advantageous where backstop can be incorporated into a bearing bore and an extension of an existing shaft can be used for an inner race.



DESIGN OF THE SPRAG provides a greater load capacity than any other type of working member. There are *more* working members (sprags) than in any other clutch-type. These new clutches, like all other Formsprag over-running, indexing and backstop clutches, have a full complement of sprags. Result—maximum torque capacity and long life in a small, compact unit.

FORMSPRAG Company
23603 Hoover Road
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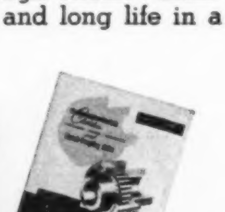


NEW CATALOG—
Send today for a copy —or write for literature on unit of specific interest to you.

F-10

Distributors in principal cities.

News Roundup

New Stainless Alloy Now OK for Welded Construction

A relatively new corrosion-resistant steel has been approved by ASME for use in welded construction. Known as Carpenter 20 Cb, distributed by Carpenter Steel Co., the new grade has been formulated specifically for those applications which involve welding during fabrication, and for those in which parts must be placed in service in the as-welded condition.

Columbium added to the original Stainless No. 20 alloy minimizes the precipitation of carbides during hot working. This permits use of the welding process in fabricating equipment too large for subsequent annealing.

Stainless No. 20 Cb can be welded by any of the standard electric-arc and resistance welding processes. Oxyacetylene welding is not recommended. Sound weld deposits can be obtained by using the welding techniques generally recommended for the fully austenitic steels. No special methods are required.

Typical applications for the alloy include mixing tanks, heat exchangers, process piping, bubble caps, metal cleaning and pickling tanks.

According to the ASME Boiler Code Committee, nine requirements pertaining to specifications and fabricating procedures of welded pressure vessels must be met. These requirements have been designated ASME Case 1188.

• • • MARINE BAND-AIDS *recently developed by the U. S. Navy will be used to repair ruptured plumbing aboard ship. This plastic patch, the Navy says, can be applied to piping carrying salt or fresh water at pressures up to 300 psi. Whether the medics or the plumbers will be called upon to apply the bandage is still in question.*

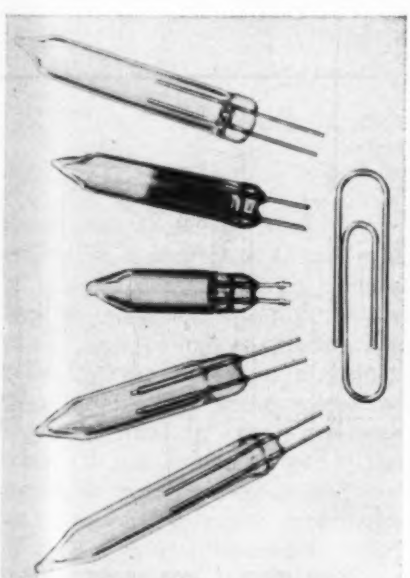
Square D Co. has acquired the property and facilities of the Iowa National Manufacturing Co. of Cedar Rapids as a wholly owned

subsidiary, it was announced recently by F. W. Magin, president of Square D. Operations in Cedar Rapids will comprise an important phase of Square D's general expansion program, according to Mr. Magin, and will supplement the company's other manufacturing facilities.

Gas Tube Makes Supersensitive Measurements

A miniature gas-filled tube has been announced as capable of extremely sensitive measurements. Developed by Decker Aviation Corp., the new transducer has been made the basis of comparative gaging equipment and pressure-measuring instruments.

Known as a gas ionization transducer, the device is a glass tube



New ionization transducer, reported capable of supersensitive measurements, consists of a glass envelope filled with gases and two electrodes

filled with gases and containing two electrodes. With proper circuitry, it is capable of converting a physical displacement, a dielectric change or an impedance change into a corresponding electrical signal.

One of its supersensitive feats, reported by Decker, was that of detecting movement in a concrete building foundation caused by a

Announcing

A New Heavy-Duty Machine Tool Limit Switch

- Trigger Fast Action
- High Contact Pressure
- Versatile In Application
- Strongly Constructed
- Long Lived

Model L-100S

Acro, a leading manufacturer of precision snap action switches, has now added the sturdy Model L-100S for the machine tool industry. Without the use of overtravel, this rugged design has repeatedly withstood 25,000,000 actuations. For installation ease, terminals and the switch mechanism are in separate compartments. The heavy cast case is gasketed for oil and moisture resistance. Available with a wide variety of actuators. Easy to service. Electrical rating 25 Amps, 125 Volts AC-DC. Favorably priced. Write for bulletin.

ACRO MANUFACTURING COMPANY

ACRO SWITCH DIVISION

COLUMBUS 16, OHIO
Plants at Columbus and Hillsboro, Ohio
REPRESENTATIVES IN ALL PRINCIPAL CITIES

YOU REALLY HAVE COMPETITION NOW

AUTOMATIC TIMING

WILL
- SAVE TIME
- REDUCE REJECTS
- INCREASE PRODUCTION

If you manufacture a product, quality timing or counting will control your processes with less wasted time . . . with increased precision . . . and will speed up production. The element of human error, increased with fatigue, often is responsible for trouble-making rejects. Eagle engineers will build a timer to answer your production problems. Send your problem today.

Write for FREE AUTOMATION BOOKLET "See What Timing Can Do For You"

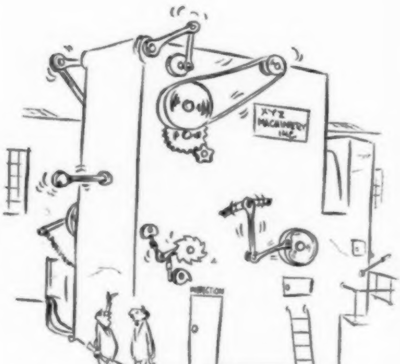
Industrial Timers by EAGLE

EAGLE SIGNAL CORPORATION MOLINE, ILL.

Eagle Timers save time, save money.

man shifting his weight from one foot to another. Practically however, the device can be adapted for seismographic measurements. It may also be incorporated into an analog measuring system and will measure any phenomenon which can be resolved into changes of capacitance, resistance, inductance or dielectric constant.

Much or its usefulness to the designer lies in the fact that it may measure many quantities without making direct contact. For instance, as a tachometer, the tube may be arranged to produce a pulse of several volts at each revolution of a rotating part without touching the device. It has also been adapted as a comparator micrometer to measure displacements as small as 0.000001-inch without contacting the part. Pressure indicators having a resolution of 1 micron of mercury use the new transducer.



"You mean I was supposed to design it to DO something?"

Convair, a division of General Dynamics Corporation, announced the purchase of a wind-tunnel instrumentation system for the U. S. Air Force. Tunnel test information in useable form will be in the hands of design engineers within 48 hours, cutting 43 days from the time formerly required. Designed and constructed by Consolidated Engineering Corporation, Pasadena, California, the revolutionary

News Roundup

electronic pressure measuring system can monitor 200 separate wind-tunnel pressure points at a central location in less than two minutes.

Engineering Least Popular With Women

Mathematics and biology attract women students in the greatest numbers, whereas engineering draws the fewest, according to the record of earned degrees in 1953.

Women comprise one-third of the total college population, according to the Engineering Manpower Commission. The percentage

Percentage of Women Earning Degrees in 1953

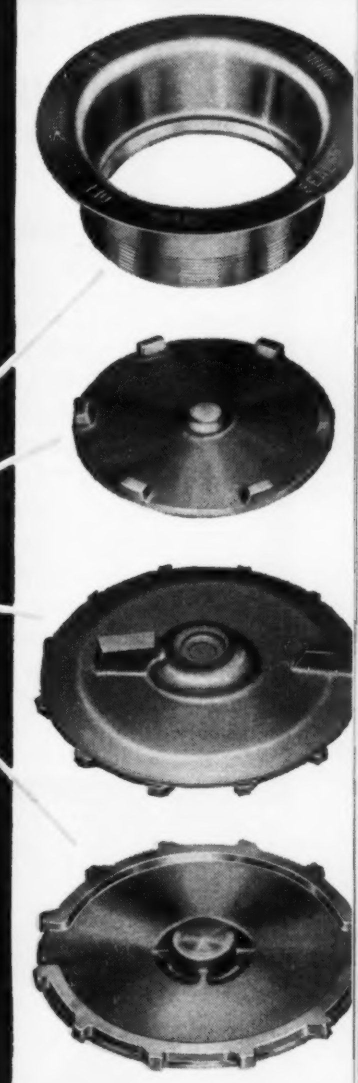
	Bachelor's	Master's	Doctor's
Mathematics ..	29	16	6
Biology	28	18	12
Chemistry	19	10	5
Geology	4	2	2
Physics	4	5	1
Engineering ...	0.15	0.03	0.02

drops slightly at the master's degree level. Fewer than 10 per cent of doctor's degrees go to women. Among the sciences only mathematics and biology approach the norm in the undergraduate field. Both follow the same curve of rapid decline in the graduate schools. As compared with the record in social sciences and humanities, only a small proportion of women take advanced training for the master's degree. Except for biology, the number who take the Ph.D. is negligible.

Annual award of $500 will go to the individual selected as having done original and outstanding redesign work in the field of metal stamping. Called the John Woodman Higgins Redesign Award, it will be presented at the spring meeting of the Pressed Metal Institute in May, 1955. For details of the contest, sponsored by Worcester Pressed Steel Co., write to

MUELLER BRASS CO. forgings* contribute to the efficiency of this modern waste disposal unit

***MUELLER BRASS CO. facilities include: designing, die-making, forging, tooling, machining, polishing, plating and assembly**



Three Mueller Brass Co. forgings play an important part in the fine operating performance of this modern waste disposal unit made by the Eureka-Williams Co., Division of the Henney Motor Co., Inc. This unit does a speedy and thoroughly effective job of pulverizing garbage and has made life easier for American housewives. The impeller disposer that chops up the waste food in the disposal unit, the disposer cover and the sink mounting flange are all forged by the Mueller Brass Co. This is another outstanding instance where Mueller Brass Co. forgings have improved product performance and cut costs. High quality forgings can be produced from standard and special brass, bronze and aluminum alloys. And in addition, the Mueller Brass Co. offers complete service ranging from product design to finished part . . . Write today for complete information and new 32 page forgings handbook.

1. Sink mounting flange, forged, machined, nickel and chrome plated by Mueller Brass Co.
2. Machined and finished disposer cover forging.
3. Cutting side of impeller disposer forged from 600 series bearing bronze.
4. Reverse side of impeller disposer.

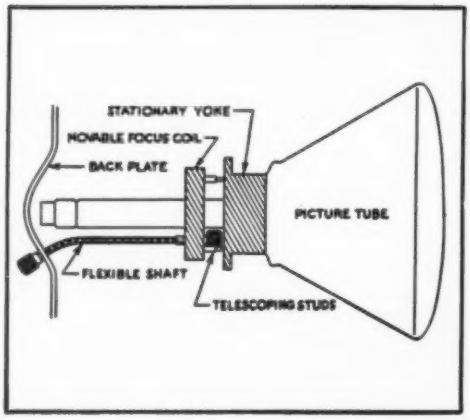
MUELLER BRASS CO.

PORT HURON 15, MICHIGAN

COST-SAVING IDEAS FOR DESIGN ENGINEERS

S.S.WHITE FLEXIBLE SHAFTS MEET CONTROL PROBLEMS CONVENIENTLY, ECONOMICALLY

Here's a typical example. A standard non-magnetic S.S.White flexible shaft is used to connect the focusing knob mounted on the back plate of a TV to the focusing coil on the tube. The fact that the shaft eliminates alignment problems is a distinct advantage which results in important savings in manufacturing and assembly costs.



SIMPLIFY YOUR CONTROL PROBLEMS

S.S.White remote control flexible shafts are available in a wide range of sizes and characteristics to enable you to meet almost *any* control requirement. You'll find them extremely useful especially where you have to transmit control around turns or where alignment is a problem.

BULLETIN 5306 has basic information and data on flexible shaft application and selection. Send for a free copy. Address Dept. 4.

R-4

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
10 East 40th Street
NEW YORK 16, N. Y.

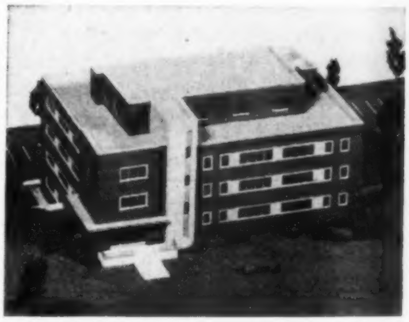
Western District Office • Times Building, Long Beach, California

the Pressed Metal Institute, 2860 East 130th St., Cleveland 20, Ohio.

Dumb Waiter to Carry Lab Instruments

One feature of the new $1.6-million electrical engineering building being built at Case Institute of Technology is a dumb waiter for laboratory instruments. Heavy oscilloscopes and delicate meters will be carefully handled without danger of being dropped.

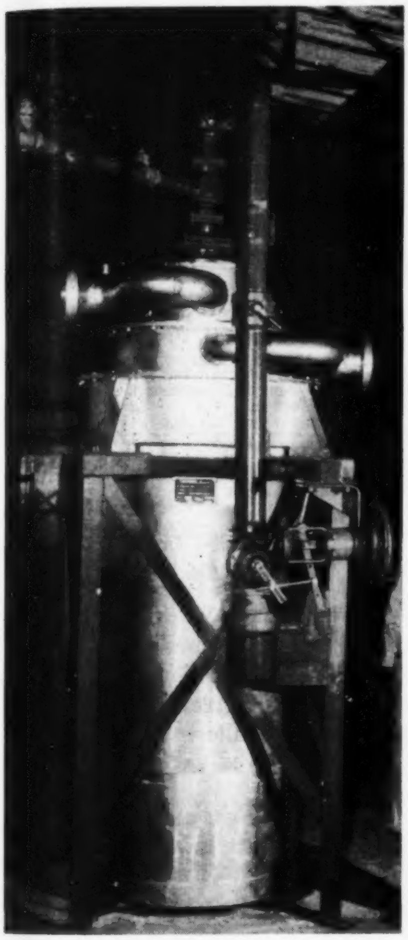
Five stories high, the new building also will feature a closed-loop television circuit between every room of major importance. Main lecture rooms and the standards room will be air conditioned. A special searchlight corridor and a fully equipped darkroom are included among the laboratories in the building.



Model of Case Institute of Technology's new electrical engineering building. Expected to be completed in 1955, the new building will replace one built in 1895

Wide varieties of ac and dc voltages will be available in every research room through a versatile switchboard system. Special computation rooms, an electrical engineering library and a lounge-conference room round out the facilities.

Federal Fawick Corp., manufacturer of brakes and clutches for heavy industrial machinery, has changed their name to Fawick Corp.



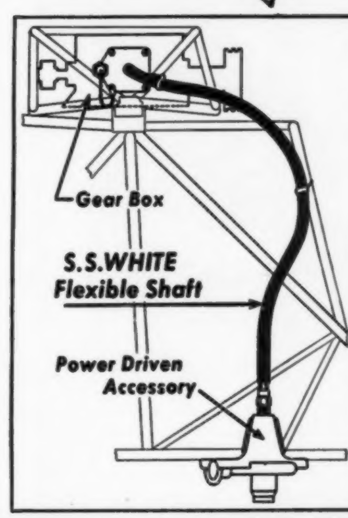
HEAT TRANSFER at the rate of 8 million Btu per hour is accomplished by a heat exchanger built by Thermal Research and Engineering Corp. Pictured above is a 2½ million Btu unit, slightly smaller, but the same configuration as its higher-capacity counterpart. These units are used in connection with test facilities on aircraft gas turbine engines

Joy Manufacturing Co., Pittsburgh, Pa., announces the election of John Lawrence as executive vice president. In announcing the election, J. D. A. Morrow, president, said that Mr. Lawrence, in addition to assuming the responsibilities normally associated with his new post, will give special attention to Joy efforts toward further diversification of the company's product lines.

COST-SAVING IDEAS FOR DESIGN ENGINEERS

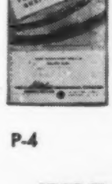
S.S.WHITE FLEXIBLE SHAFTS MAKE EFFECTIVE, LOW-COST DRIVES FOR PARTS AND INSTRUMENTS

The drawing illustrates the point. In this case, an auxiliary pump mounted on the bottom of a helicopter fuselage had to be driven from an accessory gear box. By using an S.S.White flexible shaft to transmit power between the two parts, the drive was accomplished with a minimum of parts and with big savings in installation and assembly time.



FLEXIBLE SHAFTS OFFER MANY ADVANTAGES

They are easy to install, they save parts, are completely dependable in operation, and often make possible simplifications in design which result in improved operation and lower manufacturing costs. It will pay you to investigate their advantages in your own products.



BULLETIN 5306 gives details on how to select and apply flexible shafts. Send for your copy. Address Dept. 4

P-4

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PRE-SET, TAMPER-PROOF TIMING

Practically non-breakable, Durakool Pre-set Timer Relays have more than proved themselves on the roughest and toughest jobs that could be found. Year by year, their use increases in sensational fashion. Controlled time available from .15 to 20.0 seconds in either normally open or normally closed actions. 3 to 4 week delivery. No waiting. Your production schedule is met.

- ★ No false contacts
- ★ No chatter
- ★ Quiet in operation
- ★ Eliminates double contacting or breaking of circuit

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ALL-STEEL MERCURY

Timers

Vacuum Melting Helps New Alloy Development

A new alloy designed specifically for jet engine buckets, with less nickel but more cobalt and higher titanium has been announced. General Electric's Carboloy Dept. will produce the new alloy, designated 1570, by vacuum melting techniques. It is made for higher temperature operation than presently available M-252 alloy.

A nickel base alloy, air-melted M-252, has been used for jet engine turbine buckets for several years. Its properties have been considerably improved by vacuum melting techniques, reports Carboloy. Uniformity has also greatly increased.

Application of vacuum melting techniques have made possible the development of these new alloys, according to GE engineers. New vacuum melting furnaces being installed will range in capacity from

(Continued on Page 38)

**Typical Analyses
Vacuum Melted High-Temperature Alloys**

Element	M-252	1570
Carbon	0.15	0.20
Chromium	19.00	20.00
Nickel	55.00	28.00
Cobalt	10.00	38.00
Molybdenum	10.00	....
Tungsten	....	7.00
Iron	2.00	2.00
Titanium	2.50	4.00
Aluminum	1.00	....

**High Temperature
Mechanical Properties**

Temp (F)	Stress to Rupture, 1000 hr (1000 psi)	Tensile Strength (1000 psi)	Yield Strength (1000 psi)
M-252, vacuum melted			
1500	18	91	84*
1600	11	60	..
1570, vacuum melted			
1500	24	82	58†
1600	15	52	45†

* 0.02% offset. † 0.2% offset.

Sketch of General Electric's 1000 pound vacuum melting furnace being installed at the Carboloy Dept. The unit, being built by Consolidated Vacuum Corp., will operate semicontinuously. Control panel for melting and the charging unit are located on a mezzaine floor

MACHINE DESIGN
DECEMBER, 1954

Encouraging Technical Competence

IT IS COMMON observation that engineers from continental Europe, as well as physicists from our own and other countries, are playing a major role in advancing the frontiers of engineering design. Overcoming language and other handicaps, to say nothing of possible prejudices, these people have brought to the job superior scientific and mathematical competence which the run-of-mine home-grown engineer seems to lack.

It would be easy to blame our system of engineering education for a situation that is, to say the least, shocking to the complacency of engineers. But the true causes lie deeper. Industrial management, and engineers themselves, share the responsibility.

The typical engineer in continental Europe carries his advanced engineering degree like a title of nobility, and the prestige extends even to his family. His standing in his company and the community is just as high by virtue of his technical position as that of his colleagues on the administrative side. There is therefore a real incentive for a man to dedicate himself to the highly technical sides of engineering.

Contrast the attitude here. With notable exceptions, the rewards in both prestige and money are reserved for those who depart from purely technical engineering into sales and executive positions. In engineering itself much of the work is practical—based on fundamentals and experience applied with common sense. But often little advanced thinking is required, and the highly technical phases are seldom accorded the consideration they deserve—a common fate of minorities, even important ones.

This state of affairs, and the attitudes behind it, have their inevitable effect on engineers themselves and, in turn, on engineering education. How often do we hear the "long-hair" engineer referred to in condescending, if not contemptuous terms? And in how many U. S. engineering colleges is the high-IQ student who tries to avail himself of his educational opportunities dismissed by his fellows as a mere "grind"?

Yet the increasing complexity of engineering is demanding minds trained in mathematical concepts, for example, not just the routines of figuring. Acquisition and maintenance of such a mind require an attitude of dedication—maybe even a willingness to neglect areas of personal development that, under current conditions, are more likely to lead to promotion. Physicists and mathematicians, even in this country, hold intellectual accomplishment in relatively higher regard. The result is a high standard of technical competence.

If practical engineers would show their respect and admiration for brain power, management would take the cue. With improvement in the social and economic status of the highly technical engineer there would be fewer migrations to sales and administration and more incentive for young engineers to strive toward an intellectual goal.

Colin Carmichael
EDITOR

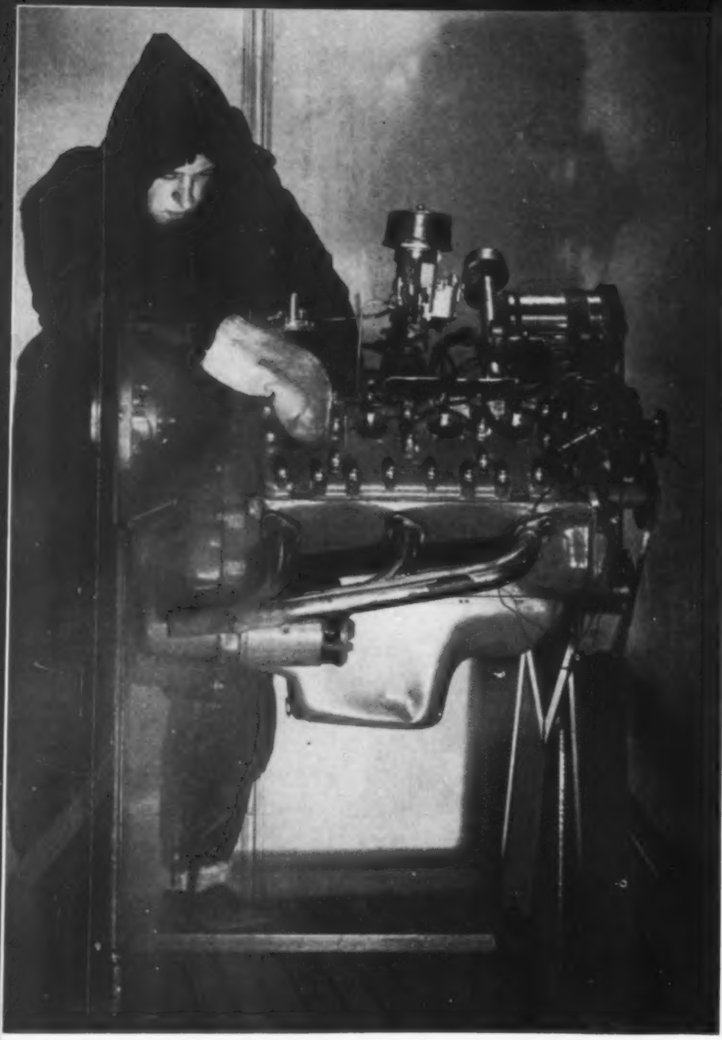


Fig. 1—Above—Stock model automobile engine in the cold chamber. Temperature in the chamber is −65 F. Next, the engine will be tested to check performance of each component

Fig. 2—Range of average air temperature from sea level to 70,000 feet. This curve shows how thermal shock to aircraft equipment may occur from take off to normal flying altitudes

By Alan E. Surosky

Manager, Engineering Division
United States Testing Co. Inc.
Hoboken, New Jersey

DURING World War II, men and machines were required to operate in environments in which the forces of nature were often more formidable than the enemy. Since then our military commitments have widened the range of environmental stresses to be anticipated. Equipment designed for use under stable conditions in moderate climates has failed lamentably when exposed to these extremes. Hence new equipment must be tested under conditions simulating those it will meet in service. This testing requires the most exacting standards of performance. It also entails, on the part of the equipment designer, a realistic understanding of the severity of environmental extremes and an understanding of how these might affect equipment performance.

The manufacturer who attempts to convert from commercial to military production today faces several hazards in time and cost estimation. Manufacturing to environmental specifications can be many times more costly than manufacturing to commercial standards. Moreover it is not unusual for testing costs and time to consume a major portion of the total available budget of these precious items. With this warning to management let us consider environmental testing and the restrictions it imposes upon the design engineer.

Philosophy of Environmental Testing: The production of planned, controlled atmospheric and mechanical environment for the purpose of testing equipment and material is not a new concept to a large segment of American industry. Today's vast expansion of transportation facilities and markets has brought with it the problem of how to maintain product quality, both while transporting the product and during service in extraordinary environments.

Environmental, or simulated service testing concerns itself not only with the effects of natural meteorological forces, but also with the mechanical forces created by man, such as shock, vibration acceleration, and explosive, corrosive, or erosive atmospheres.

Environmental testing had its disorganized origins in the plant of every manufacturer who

Environmental Testing

How equipment tests under laboratory-made hazards can help designers reduce field service failures

was ever confronted with unexpected product spoilage. A candy maker found that certain batches of his chocolate, satisfactory in Chicago, exhibited disconcerting evidence of fat separation in Miami. Through testing of samples in small ovens it was possible to separate those batches which were suitable to the high-temperature cycling conditions undergone in shipment to and storage in semitropical areas from those which could be acceptably disposed of only in temperate zones. From such humble beginnings the impetus of World War II inspired and promoted the growth and development of the highly organized and scientifically conceived principles of testing for effects of environment available today.

No better way of determining the behavior of a product has been developed than to submit it to actual service.[1] Since this is almost always impracticable due to the inordinate time and cost, the usual approach is through a laboratory test program. In specifying a program of simulated service tests, factors of environment must be carefully weighed with regard to the type of service anticipated and the nature of the item itself. A program should be sufficiently severe to test a product thoroughly without requiring performance beyond economically sound standards. A watch manufacturer recently sent several of his watches over Niagara Falls with weights and balloons attached to demonstrate water and shock-proof qualities. A test of this type may be arresting, but could hardly be recommended as a practical standard procedure.

The rationale of environmental testing, then, lies in the application of well controlled and easily evaluated test methods. The type and degree of application result not only from a careful analysis of the product and its operational requirements, but also from a careful evaluation of the significance of the testing procedures themselves.

Test Methods, Specifications, and Equipment: The emergency-inspired development of environmental testing has brought forth a catalog of test procedures which presents an ominous appearance to those who attempt for the first time to describe a valid test program. The Air Force by necessity has achieved more uniformity and greater technical advance in this field of testing than any other group. Air Force procedures are enthusiastically recommended, not for their perfection, but because these are the soundest and best organized procedures currently available. Environmental performance requirements are governed by numerous specifications, but the salient features of these are well represented by the reference test procedures promulgated under the Air Force specifications for environmental testing.[2] This specification may be considered categorical with regard to

Fig. 3—Salt-spray test is a means of determining the action of a corrosive environment on various samples such as cadmium and zinc plated parts, prrotective coatings including paint and alloys

Table 1—Typical Effect of Thermal Change in Aircraft Components

Component	High Temperature Effect	High Temperature Consequence	Low Temperature Effect	Low Temperature Consequence
Synthetic rubber parts	Lose plasticizer	Harden, shrink, distort, tear	Lose resilience	Crack, break
Closure, sealing strips	Polymers degrade	Stick to contacting parts	Lose resilience	Break
Plastic parts	Lose plasticizer	Discolor, crack, craze	Lose resilience	Crack under vibration, shock
Plywood	Lose moisture, undergo partial pyrolysis	Discolor, bulge, crack, check	Only slight	Not critical in most cases
Dissimilar metals, close tolerances	Differential expansion	Binding of moving parts; loss of effective seal	Differential contraction	Binding, seizing of moving parts (also freezing with humidity), loss of seal
Lubricants	Vaporize, become more fluid; expand differentially with metals	Reduced lubrication, increased friction	Increase viscosity contract differentially with metals	Reduced lubrication, increased friction and torque

Fig. 4—Fungus growth after 28 days in the tropical chamber is being examined. Tropical conditions may be simulated by means of the humidifier and heating elements. Humidity may be varied over a range from −5 per cent to +95 per cent. Temperatures from −50 F to 86 F may be obtained

environmental test procedures.

Some familiarity with test equipment is essential to an understanding of environmental design requirements. Without going into details, suffice it to say that each unit is designed with appropriate materials of construction and methods of application, measurement, and control for those factors of environment which it will duplicate. The test chamber or machine must be built to withstand continuously those stresses of environment which it can create.[3]

To indicate the scope of environmental testing, some of the more important elements that may influence service failure will be discussed. Since the total environment is variable in service, it cannot be simulated or programmed with predetermined control. It is necessary to isolate one, or at most two, factors for study at one time. After all the expected environment factors have been studied, their influence upon each other must be weighed. A look at the overall picture will then give the most valid judgment of the results.

Temperature Effects: Both high and low temperatures affect all types of equipment. While slow cycling between temperature extremes entails some additional consequences, rapid changes over large temperature ranges introduce effects of a critical nature. Such rapid changes are known as thermal shock. Results of thermal shock are not generally predictable from high and low temperature behavior taken separately. Its influence should always be determined when thermal shock is known to exist in the intended service environment, *Fig.* 1. Typical effects of thermal change for various components and material combinations found in aircraft are listed briefly in *Table* 1. The listing is only a partial sampling of potential trouble spots, yet is sufficient to characterize the "nightmare" quality of the design problem for this critical end item.

Operational tests of components or complete assemblies may be conducted at any temperatures appropriate to the expected environment. The range for aircraft equipment and parts is generally from −65 to 185 F, *Fig.* 2. Thermal shock in aircraft service may subject certain parts to changes of 225 F within a few minutes, as in the rapid climb to high altitudes from a desert takeoff. The principal effect of such exposure is rapid differential contraction of dissimilar materials, with consequences as shown in *Table* 1.

Humidity: One of the most severe elements of service environments is ambient moisture, especially at elevated temperatures. For metals, corrosion is the most serious consequence. Bare surfaces of nuts, bolts, screws, gears, or cams of the more susceptible metals provide excellent focal points for failure. It is more important in this respect to consider the possible avoidance of dissimilar metal contacts. The latter may promote rapid galvanic corrosion in the presence of moisture. Vulnerable locations are found frequently at threaded, riveted or bolted joints, at bearing or sliding contacts and at spring seatings. Full assembly tests are a necessity in a complex of metals and finishes. Data on open circuit galvanic potentials, even where available, are too often modified and even reversed, under service conditions, owing to polarization effects.

Electrical equipment is subject to malfunction even after only a short exposure to humid atmosphere. Sensitivity or range of tuned circuits may be lost through altered electrical constants if moisture is absorbed by resistors, capacitors, or electrical insulation. Effective design of such equipment leans upon the use of moisture-resistant potting resins, low or nonabsorbing insulating materials such as Teflon and polyethylene or, when feasible, hermetic sealing.

Too frequently, when the end item is intended for use in an environment of low or moderate relative humidity and temperature, the vicissitudes of shipment to the service point are overlooked. Many machines, devices and instruments have suffered serious premature damage through neglect to provide packaging appropriate to a sea voyage in an open freighter hold through the Panama Canal.

Altitude: The effect of high altitudes may be pronounced in certain types of equipment. For example,

1. Internal combustion engines are dependent upon atmospheric oxygen content. Power output and efficiency go down with increasing altitude.
2. Non-hermetically sealed electrical and electronic equipment are affected through lowered insulation properties. Wear of brushes on motors and generators, and severe arcing at contacts, breaker points or switches increase at high elevations. These phenomena are obviated by positive hermetic sealing.
3. Many instruments operate on differential pressure. Here sealing is mandatory even at nominal altitudes if sensitivity is important.

As pointed out previously, the need to protect

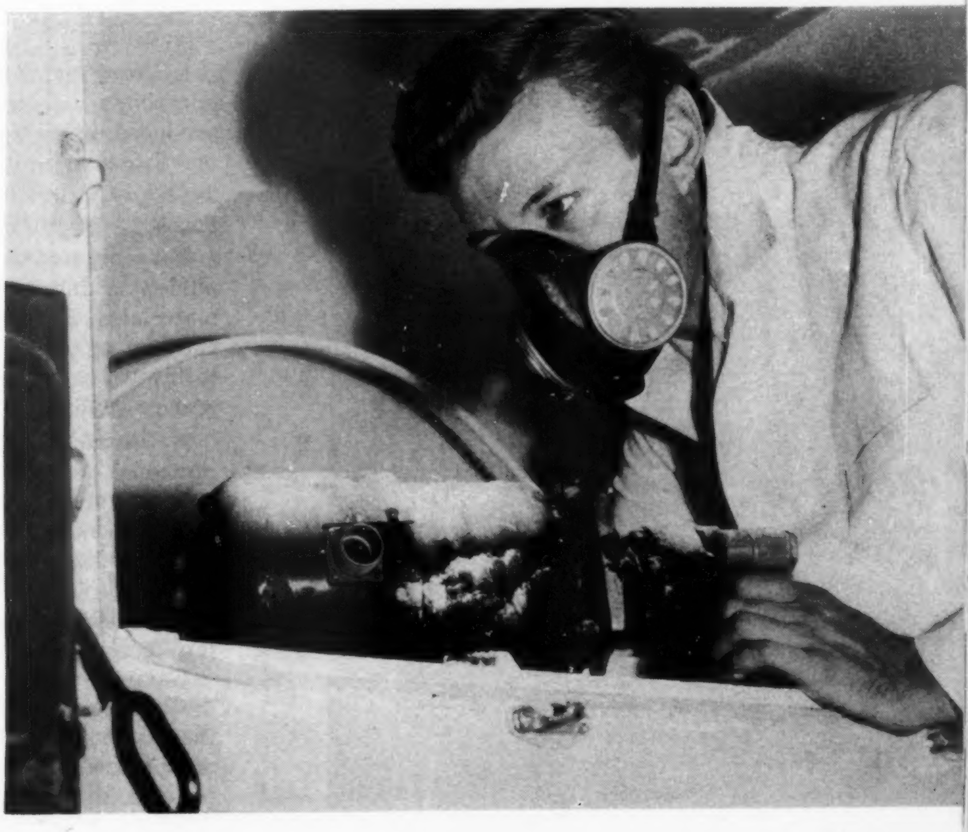


Fig. 5—Effects of fine desert sand or dust at temperatures up to 160 F may be simulated in the sand and dust chamber. Here, an aircraft motor-driven hydraulic pump is examined after a 24-hour exposure

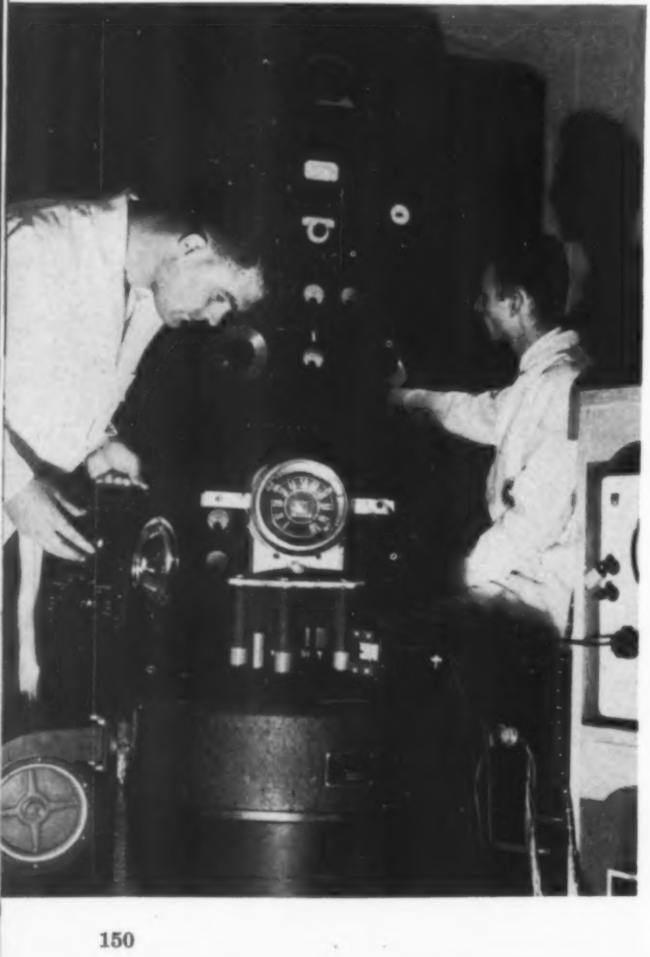
items in shipment by air should not be overlooked if such items are sensitive to lowered barometric pressure or to rapid changes in ambient pressure. The reminder is unnecessary for those who have suffered ink baths when attempting to use their fountain pens in a plane.

Salt Atmospheres: Corrosiveness of marine and coastal atmospheres in almost every climate, and particularly in torrid zones, is proverbial. This is due in large part to the droplets of salt-laden moisture always present in the air over the sea. Their influence normally extends some 900 feet inland. During stormy weather, salt spray is known to be carried many miles into the interior of land masses, leaving deposits of salts, the effects of which may be registered for some time afterward.

The salt spray test, *Fig.* 3, in one form or another, has for many years been employed for estimating within a few days time the probable effects of marine or near-coastal exposures. Its use has extended from research on new metals and finishes through standard quality control procedures applied in the production of finished items.

A recent, critical evaluation[4] concluded that salt spray tests in themselves have been a handicap to progress as a research method for the development and improvement of metals and finishes. However, the test finds valid use in the inspection of a regularly produced product provided a standard level of performance has been established.

Fig. 6—Vibration test of an automobile speedometer being carried out on a 5 to 2000 cps vibration unit. A stroboscopic search for resonant points on the speedometer is made at the same time



Microbiological Effects: Application of modern technology to subtropical and tropical environments has renewed and intensified emphasis upon retarding or preventing the deterioration of materials by micro-organisms. Degradative bacteria and fungi are present in active or latent condition throughout the world. In warm, humid climates this ubiquitous potential is released most destructively. Almost all organic substances are subject to microbial deterioration. Notable among the commonly used materials are those based upon cellulose (wood, paper, textiles); many plastics with plasticizing ingredients and organic fillers; animal and vegetable oils as such or in paints and protective finishes; leather; hair felts; and glues or other bonding agents. Even when basic mechanical features of assemblies or equipment are not affected, the growth of micro-organisms which find sustenance in the ordinary protective finishes will foul optical components or instruments, or change the design constants of electronic elements.

The approach to prevention of degradation or fouling of this type depends upon knowledge of the severity of the environmental exposure to be expected, the susceptibility of the component materials and finishes, the availability of preventive treatments, and the economics of their application. The treatments fall, in general, into three categories:

1. *Provision of a physical barrier* to entrance of microbiota or moisture. Since few products are produced under biologically sterile conditions, there may be enough viable molds or spores and moisture locked in to initiate damage when optimum temperatures are attained for extended periods.

2. *Incorporation of toxic inhibitors.* A host of mildew inhibitors have been developed for various materials. Effectiveness of treatment may be lost through volatilization of inhibitor, and its corrosive influence, or that of its breakdown products, under service conditions.

3. *Chemical modification* of the material to be protected, which "builds-in" a non-nutrient character toward molds and bacteria. Acetylation, and more recently, cyanacetylation which can be applied to cotton fibers or finished textile constructions are pointing the way to effective permanent modification of ordinarily vulnerable cellulosic materials.

Environmental tests for resistance to microbiological deterioration, *Fig.* 4, depend upon the anticipated service environment and the manner of use of the item. They range from field exposures in tropical test sites to the use of labora-

tory controlled tropical chambers. The test organisms may be employed in pure culture or mixed culture inoculations. They may also be derived from the use of soil suspension or soil burial techniques.

Radiant Energy Effects: Sunshine is the principal influence in service which may cause damage from radiant energy. Absorption of the longer heat waves generally raises the temperature of most materials. Visible and ultraviolet portions of the solar spectrum promote deterioration of textiles, rubber, plastics, paints, lacquers, varnishes, paper, and dyes especially in the presence of moisture and oxygen.

Sun lamps having appropriate spectral energy distributions are employed in accelerated laboratory tests. The time and other conditions imposed are determined by the anticipated service environment.

Corrosive and Erosive Atmospheres: The effects of salt spray have been previously discussed. Other corrosive and erosive influences may have to be considered in the design of an item. Airborne solids such as sand are erosive at high wind velocities. Fine particles may enter enclosed assemblies to clog and abrade moving parts or change the electrical characteristics of switches, relays and other contacts. Chemical fumes of particular composition and strength may be met in industrial operations. The designer of equipment or instruments to function in such atmospheres must take steps to counteract these conditions. Fine dust, *Fig.* 5, is an excellent nucleus for condensation of moisture. When settled on metal surfaces it provides a possible condition for concentration cell corrosion, a more common occurrence than generally believed. One unusual case in the author's recent experience involved a large, surface-laid oil pipeline which had developed a pock-marked condition on its exterior surface. Each pock mark was found to be associated with a small fragment of mica derived from the local sand. This being a coastal installation, winds laden with salt spray deposited the mica flakes with a minute film of salt solution under each particle producing a rapidly acting series of salt concentration cells.

Vibration and Shock Effects: Vibration is associated with equipment which is engine operated, or which entails cyclic motion of appreciable energy and frequency. Its effects may range from a loosening of fastenings to the failure of mounting bases.

Vibration and shock in handling and transportation have caused much damage to items designed for stationary use, but which had been packed and crated inadequately. Vibration and shock may also be generated by wind and gust conditions and must be considered if failure and secondary damage are to be avoided.

Vibration and shock tests, *Fig.* 6, take many forms in the laboratory. Again, the test conditions chosen are based upon the anticipated service or transportation.

The foregoing discussions of effects of particular environmental conditions point up the hazards confronting the equipment designer. By appropriate simulated service tests this hazard may be largely reduced, if not completely eliminated. Further development of test methods will proceed as more is learned about the incidence and nature of service failures. Engineers concerned with this problem can help to advance the status of valid test development by collating and publishing service failure data.

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They Say . . .

"Science-writing is a very old profession. Science probably separated from witchcraft when science-writing began. Just so long as information was passed along by word of mouth only, it was always susceptible to control by a few for their own benefit and to mystify the many. When it began to be written about, science came up out of the atmosphere of the cauldron and the alembic."—LEWIS L. STRAUSS, *chairman, Atomic Energy Commission.*

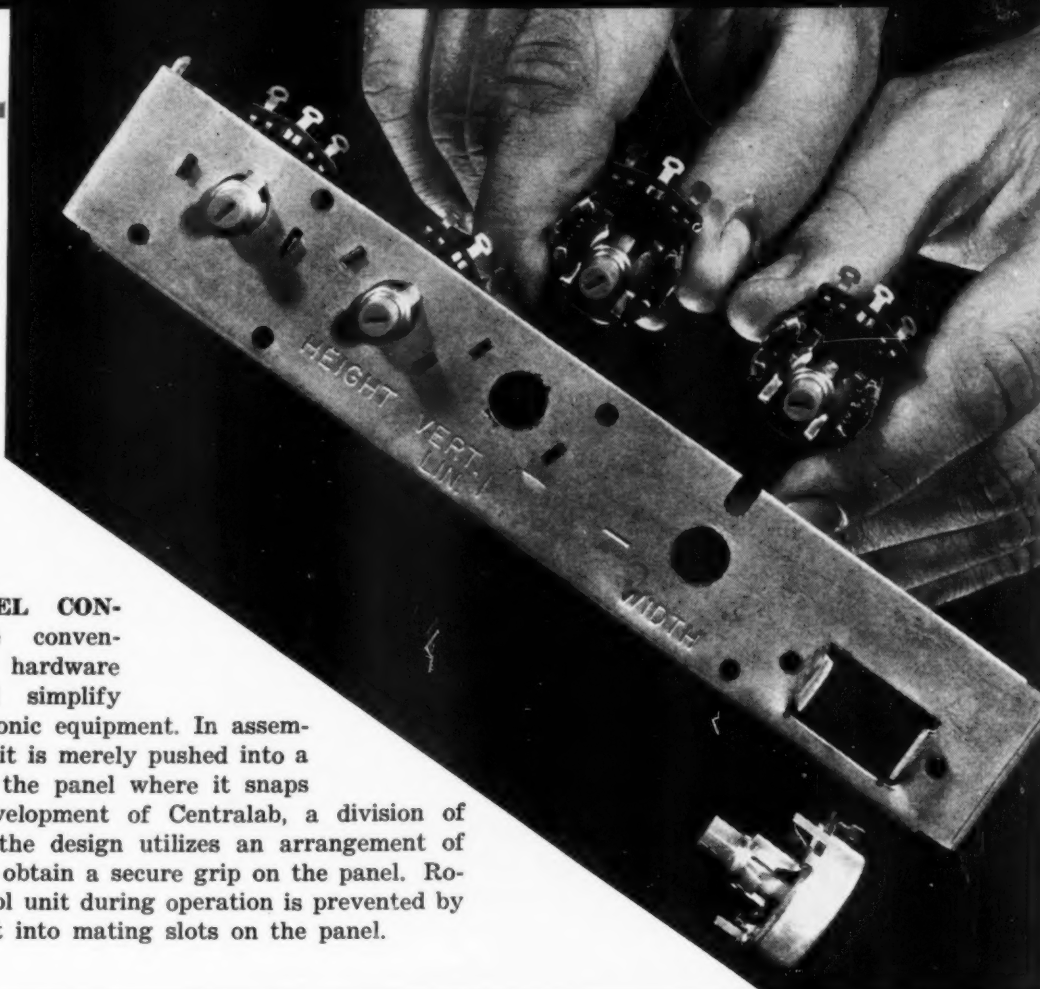
"The sciences have become so complex and workers in them have built up their own vocabularies to such an extent that a chemist has difficulty in understanding a physicist; the biologist can't talk to the geologist; none of them can talk plainly to the engineer. Sometimes the engineer can't get his ideas across to management; and few technical people can explain their aims and what they have done to the public. Now the engineer must put the scientists' fundamental discoveries on the assembly line and ultimately the public must pay for it. This can be done well and quickly only if each has a clear understanding of what the other is talking about. This breakdown in communications retards invention and stifles the fruits of it."—LESLIE C. BEARD JR., *assistant director of Socony-Vacuum Laboratories, Socony-Vacuum Oil Co.*

Correction

In *Fig.* 11 of "Clearance Design in Hydraulic Pumps and Motors," October 1954, the label for the horizontal axis of the graph is in error. It should be: VL (for circular disks $VL = R^2\omega/12$).

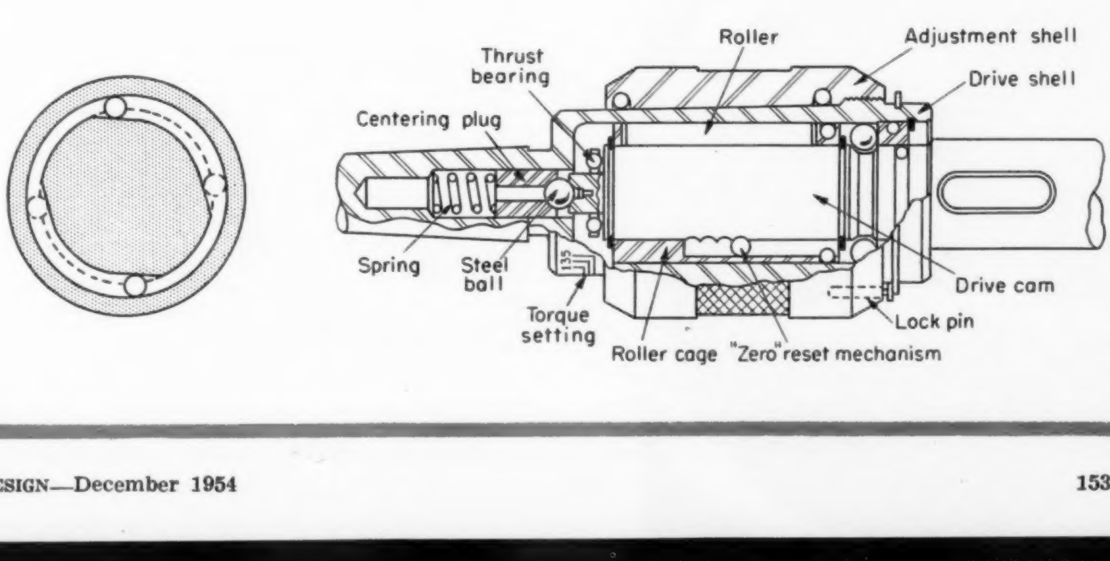
SCANNING the field for IDEAS

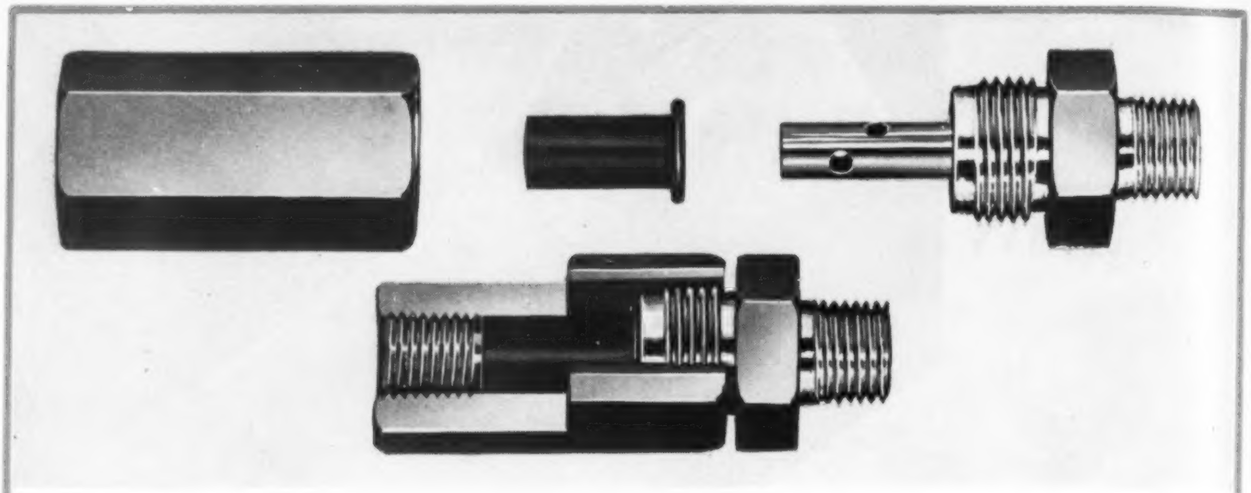
RUBBER GEAR TEETH accommodate misalignment in drive connections and minimize transmission noise under irregular load conditions. Employed in an engine drive coupling developed by Twin Disc Clutch Co., replaceable synthetic rubber blocks molded in the shape of involute gear teeth and mounted to lugs on a driven spider are used to transmit power from a mating driving ring with internal teeth. Angular and parallel shaft misalignment, as well as shock and vibration loads, are absorbed by the resilient rubber teeth, simplifying mounting problems in power-take-off drives. Where operating drive speeds fall within a critical vibration frequency range, the stiffness of the drive connection may be readily altered by varying the number of rubber teeth. Maintenance is facilitated by the design which permits new teeth to be installed without complete disassembly of the drive.



CLIP-ON PANEL CONTROLS eliminate conventional mounting hardware requirements and simplify assembly of electronic equipment. In assembly, the control unit is merely pushed into a mounting hole on the panel where it snaps into place. A development of Centralab, a division of Globe-Union Inc., the design utilizes an arrangement of six spring clips to obtain a secure grip on the panel. Rotation of the control unit during operation is prevented by tab stops which fit into mating slots on the panel.

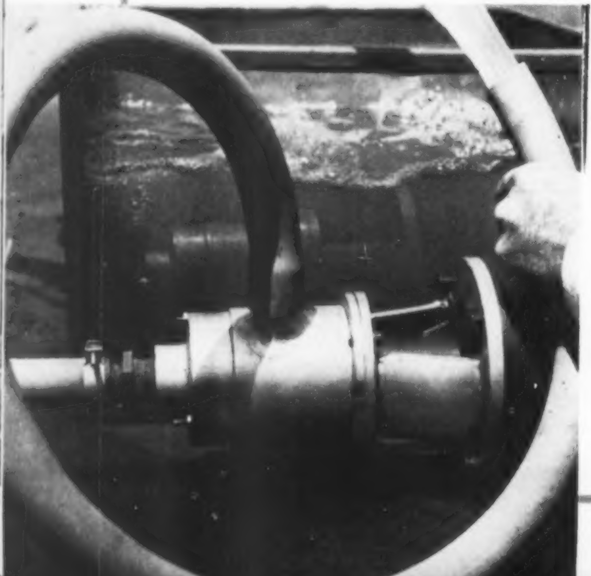
ADJUSTABLE TORQUE RELEASE to prevent overloading of power members is provided by an overrunning roller drive developed by Scully-Jones and Co. The drive may be preset to disengage at a prescribed torque value. Main operating elements of the drive are a drive shell, two rollers and an inner drive cam. Under normal conditions, torque is transmitted when the rollers are wedged between the drive shell and drive cam. However, when the driving torque exceeds the preset limit, the drive shell expands, permitting the rollers to override the cam edge onto a cylindrical surface. This action releases the drive which continues to freewheel until reset. Rollers are prevented from moving around the inner member by a no-load stop mechanism. Torque adjustment is obtained through an outer adjustment shell which, when turned, varies the permissible expansion clearance of the drive shell to alter the spring force resisting the rollers.

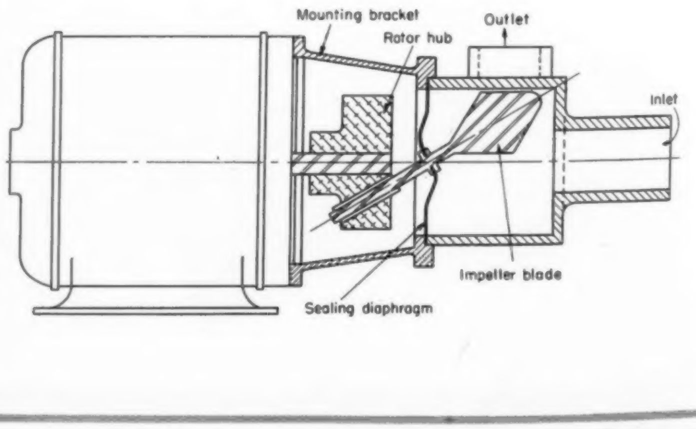




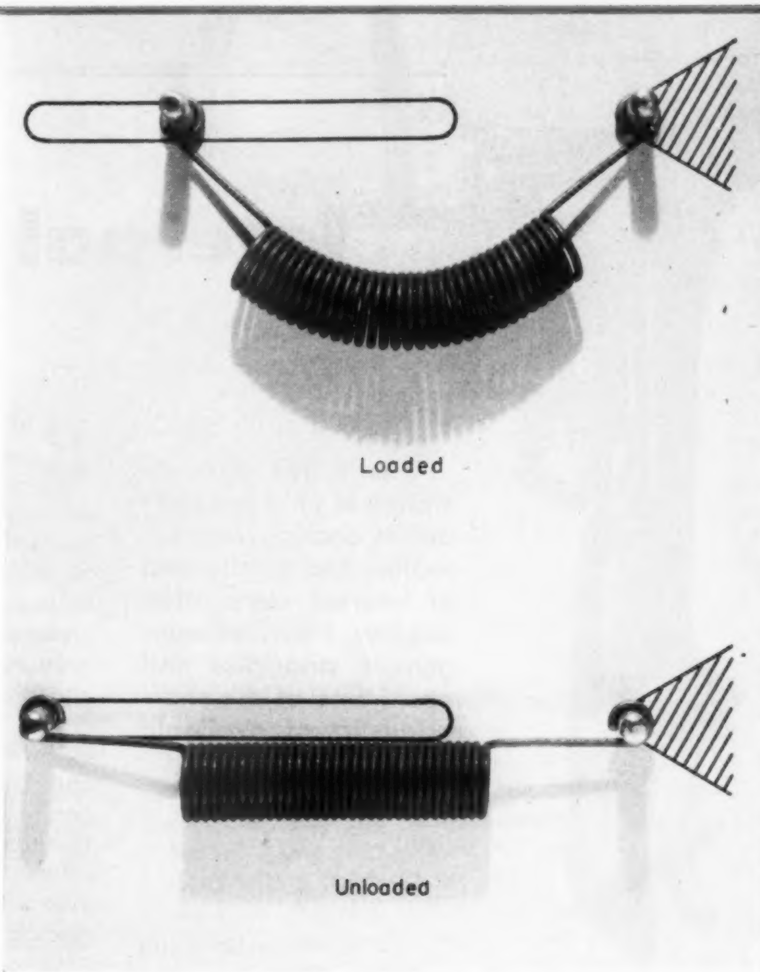
DIRECTIONAL FLOW CONTROL in a check valve for fluid lines is obtained with a novel expanding sleeve construction. Developed by Betts Machine Co., the design employs a replaceable rubber or plastic sleeve which fits over a valve stem with radial fluid passages. Fluid entering through the stem under pressure acts to expand the sleeve, permitting flow to continue through to the outlet end of the valve. If the direction of flow is reversed, however, the sleeve contracts to its normal position, blocking the fluid passages and preventing flow through the valve. Springs and moving metal parts are eliminated by the design, reducing wear and vibration effects to a minimum.

PADDLE BLADE IMPELLER, designed to operate without packings or glands, is employed in the new Vibro-Pump to handle corrosive or abrasive fluid solutions. Invented by W. Gemeinhardt and under development at H & H Mfg. Co., the pump design utilizes an oscillating diamond-shaped impeller blade to provide pumping action. The impeller blade is driven through a shaft extension which is mounted at an angle to a bearing in a rotor hub on the drive motor. The impeller shaft does not rotate but, rather, imparts a stirring or oscillating motion to the impeller blade. Sealing action is provided by a flexible rubber or plastic diaphragm which serves as the rear wall of the pumping chamber and is mounted rigidly to the impeller shaft. Although still under test, the pump has been used successfully to handle mud, slurries and liquids containing up to 20 per cent vapor. Variation of the materials in the diaphragm, impeller and pump body offer further flexibility in meeting specific application requirements.



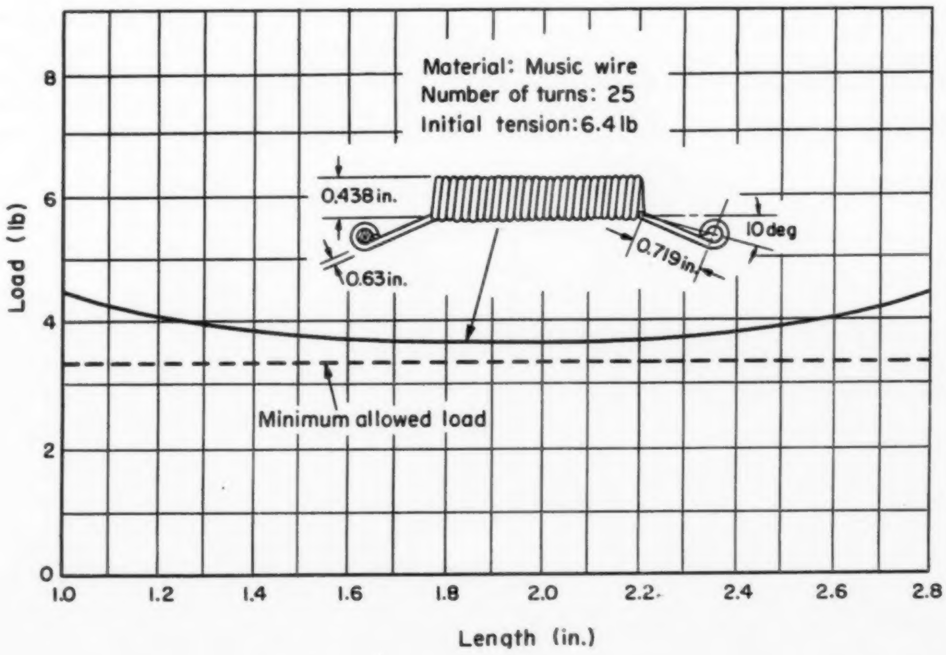


IDEAS



CONSTANT - FORCE SPRING for compression applications provides essentially uniform load independent of deflection. Resembling an extension spring in appearance, the Flex'ator developed by Hunter Spring Co. exerts force when flexed under load. In operation, compression forces are applied through arms on the ends of a helically-wound spring body. As the arms move together, the spring body buckles out, changing the wire stress and the effective moment arm of the spring force. Since the reacting force at the spring arm is a function of the wire stress and the moment arm, dimensions of the spring body can be selected to provide a resultant force that increases, decreases or remains substantially constant with deflection.

The useful deflection range of the spring arm ends is normally considered to be from the relaxed position to a position in which both arms become parallel. This range has been found to produce a slight variation in load; however, shrinking the deflection range can frequently reduce load variation to practically zero.



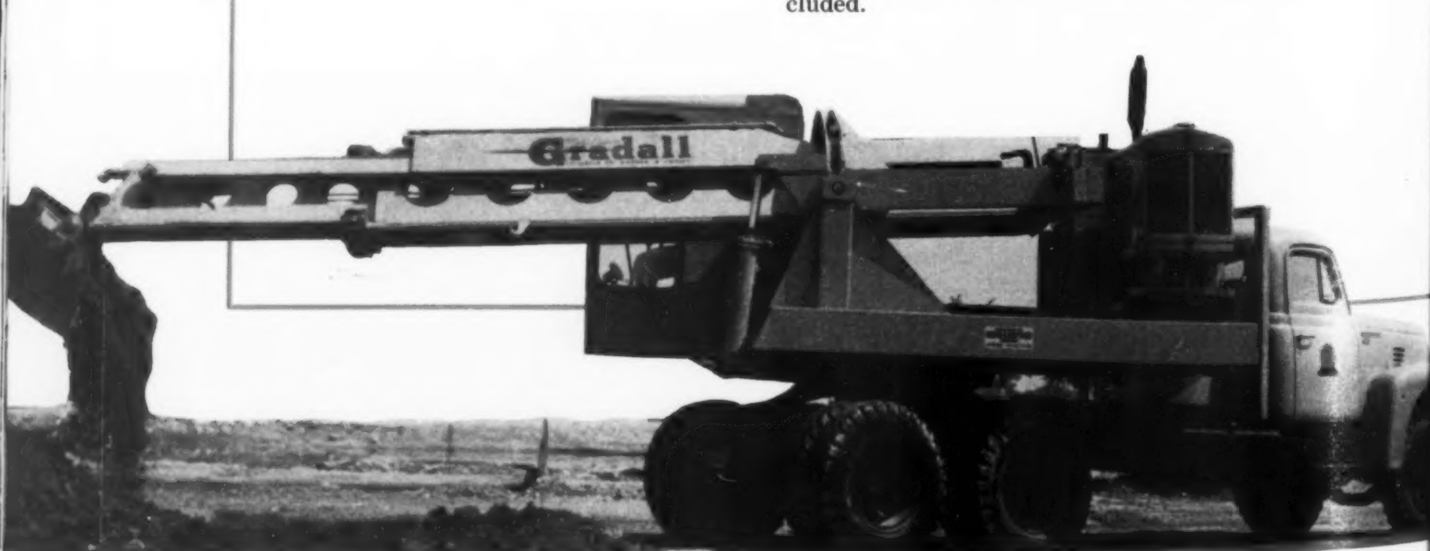
Internal Combustion

This is the first installment of a two-part article dealing with selection and application of internal combustion engines. Part 1 includes general principles and an outline of the characteristics of available gasoline engines.

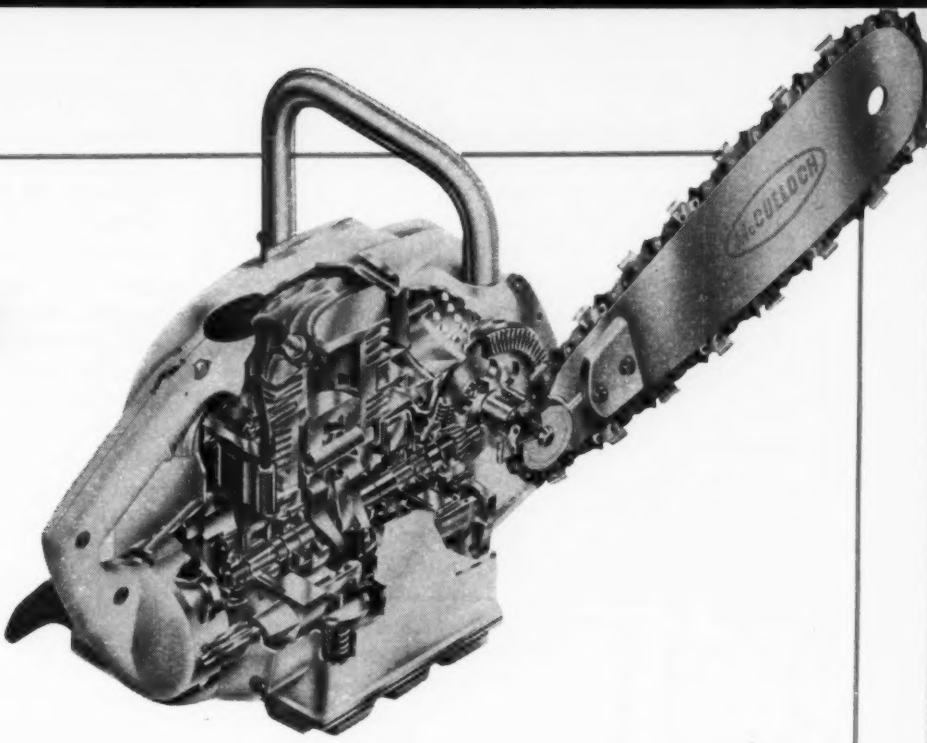
Fig. 1—How portability and mobility of engines have sparked the development of a wide variety of equipment is suggested by these four applications. Near one end of the size range are two lightweight units, top. Each, powered by a one-cylinder gasoline engine, weighs less than 40 pounds. Below, a 65 horsepower gasoline engine provides the power required to operate Warner & Swasey's Gradall. Displacing the steam locomotive almost overnight, diesel-electric locomotives, right, supply 112,250 pounds tractive effort from twin 2250-horsepower units

RECIPROCATING internal combustion engines today serve as sources of power for machines ranging from chain saws and outboard motors to road machinery and locomotives, *Fig.* 1. Many of today's applications of these engines have come into being almost entirely within the past two decades. This increased use of internal combustion engines is primarily a result of the increased dependability and power the engine designers and manufacturers have succeeded in combining in a package which is continually becoming both smaller and lighter. Another important factor, which has spurred the development of more and more machines powered by engines, is the continuing effort to replace human muscles. Engines provide a source of power which is independent of electric power lines.

Concrete evidence of the increasing use of engines is given by the fact that production of engines in the U. S. for other than aircraft or automotive use increased by 20 per cent from 1947 to 1952. More and more machine designers are, therefore, faced with the problem of engine selection. This and a subsequent article will attempt to present the factors which a designer should take into consideration when choosing an engine for a particular application. Where it affects output characteristics or other factors influencing selection, engine design will be discussed, and basic information on engines available from U. S. manufacturers will be included.



Engines—1



By Keith A. Carlson
Assistant Editor, Machine Design

Operating Principles

To be sure of an understanding of the terms used in a discussion of engine performance and efficiency, certain fundamental equations and definitions will be reviewed.

Spark Ignition Engine Cycle: A pressure-volume diagram of an idealized spark-ignition engine cycle, *Fig.* 2, or Otto cycle, shows the thermodynamic processes involved in such an engine. A gas or combustible mixture is first compressed, A to B, and ideally no heat leaves the gas. When the piston reaches top center, B, a spark ignites the mixture and while the piston is at top center all the mixture is burned, B to C. Gases then expand, ideally without heat loss, during the expansion stroke, C to D, until the piston reaches bottom center. At this point the exhaust valve opens and the pressure drops, D to A, with the piston standing still. If the burned gases were blown out and the cylinder filled with a fresh charge at this time, the cycle could be repeated. Since this cycle was completed in two strokes, it is called a two-stroke cycle. Engines operating on this cycle are usually called two-cycle engines.

Because of the problems associated with removal of burned gases and filling the cylinder with a fresh charge while the piston is at the bottom of its stroke, many engines use return motion of the piston, A to E, *Fig.* 2, to force out the burned gases and the next outward stroke,

E to A, to draw the fresh mixture into the cylinder. This is known as a four-stroke cycle, commonly abbreviated to four-cycle.

It should be remembered that both of these cycles are ideal, and only approximately attainable in practice. However, they are a convenient starting point for actual engine analysis.

It can be shown that thermal efficiency of the ideal Otto cycle engine is

$$E_t = 1 - \frac{1}{r_c^{K-1}}$$

where r_c is compression ratio or ratio of cylinder volume when the piston is at the bottom of its stroke to clearance volume, or volume remaining when the piston is at the top of its stroke, and k is the ratio of the specific heats at constant pressure and constant volume of the gas used. This formula shows that, in the ideal engine, thermal efficiency depends only upon compression or expansion ratio and the gaseous mixture used. Although actual cycles differ considerably from this ideal cycle, this serves to illustrate the increased efficiency obtainable with increased compression ratios. With air as the working gas over a range of compression ratios, efficiencies of the ideal engine result in the curve of *Fig.* 3. Since the working medium in an actual spark-ignition engine is not dry air, but a mixture of air and fuel before ignition, and nitrogen and the products of combustion after burning, theoretical efficiency of the engine is reduced to a lower value than in the air cycle, *Fig.* 4, according to the air-fuel mixture ratio.

A majority of the engines operating on the Otto cycle use a mixture of air and gasoline vapor; however, other fuels such as kerosene or gases such as propane may be used in engines designed to use gasoline as a fuel by making minor modifications in the fuel system.

With thermal efficiency, and therefore performance, increasing with compression ratio, *Fig.* 3, it is pertinent to ask why compression ratios are held at moderate values. Several practical considerations set the limit. Two of them are related to fuel characteristics—preignition and detonation.

Because the mixture compressed is explosive, it will ignite of its own accord, *prior to* the spark, solely from the heat of compression, if compression is too high. This is called preignition and can also occur in an overheated engine or one with heavy carbon deposits.

Detonation, knock or ping is a different phe-

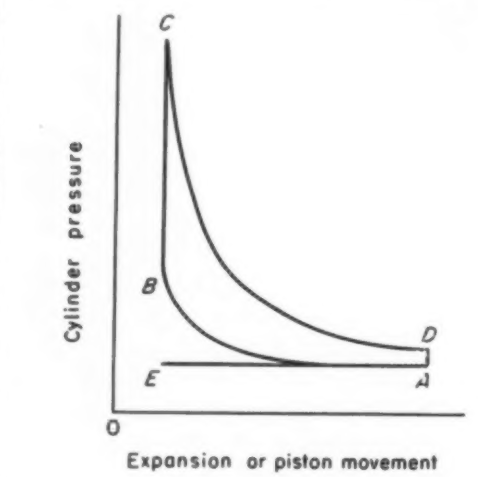


Fig. 2 — Pressure-volume diagram of ideal spark-ignition or Otto cycle engine

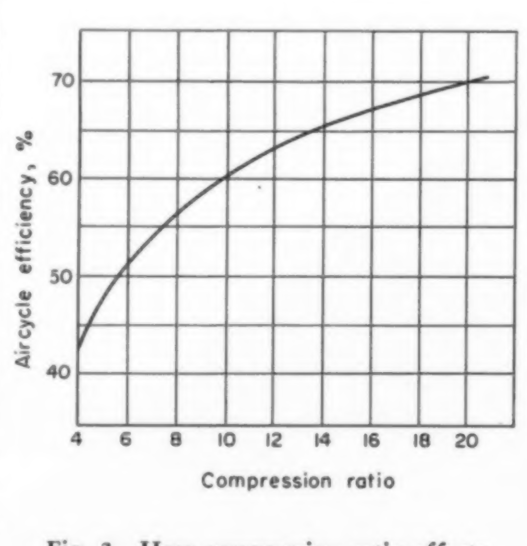


Fig. 3—How compression ratio affects efficiency of an ideal engine using air as the working medium. Compression ratios of spark-ignition engines do not exceed 9 to 1, those of diesels usually are considerably higher

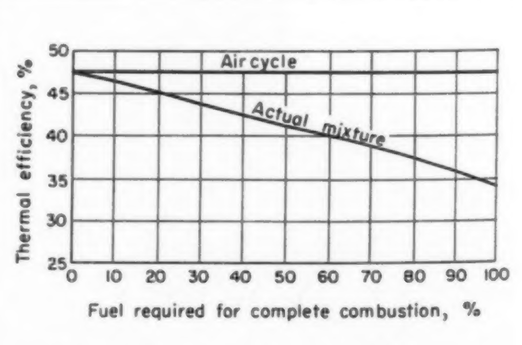


Fig. 4—Lean fuel-air mixtures in gasoline engines increase ideal thermal efficiency, as in this engine with a compression ratio of five to one

nomenon, which occurs *after* the spark. In normal combustion a flame travels across the mixture like a burning match stick. The flame compresses the unburned mixture ahead, overheating it to the point where it can explode violently and simultaneously with high, destructive pressures. Good combustion chamber design, ensuring proper cooling of the last part of the charge, can prevent this but regardless of design, too high a compression ratio causes detonation. High-octane fuels contain an ingredient which inhibits detonation. Otherwise, high-octane fuel confers no advantage and should not be specified or used unless needed to decrease detonation.

Because a weak mixture has higher thermal efficency, *Fig.* 4, it may be desired to operate with such mixtures for economy's sake. This is good up to a point. But as mixture is weakened, burning becomes slower and more erratic, with consequent misfiring and burning of the exhaust valves. If a mixture adjustment is provided on the engine, the user should be warned to adjust for smooth running and not to attempt over-weakening. An over-rich mixture is less damaging, until the point is reached when raw fuel washes lubricant off the cylinder wall and dilutes the crankcase oil. At this point, however, power is falling off and the engine response is sluggish.

The best mixture for maximum power is about 20 per cent richer than the amount of fuel theoretically required to burn all the oxygen in the air. This is because of incomplete mixing and combustion, and a phenomenon known as "dissociation." At high temperatures, such as in a flame, gases such as CO_2 and H_2O, the normal combustion products in an engine, partially break down or dissociate into CO, O_2, and H_2 with consequent loss of some of the heat of combustion. Extra fuel helps compensate for this loss and burns the liberated O_2.

Apart from fuel considerations, high compression ratio means higher combustion pressures and therefore heavier working parts. Also, wear

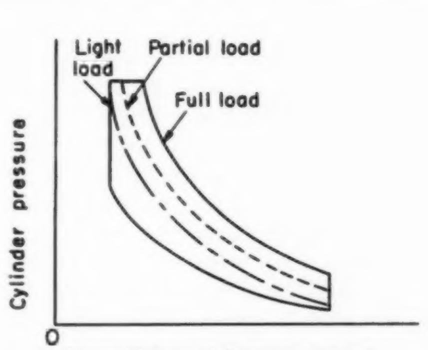


Fig. 5—Pressure-volume diagram of compression-ignition or Diesel engine cycle

causes a greater falling-off in efficiency of a high compression engine and maintenance in peak condition is therefore more difficult.

Diesel Cycle: In the ideal cycle for a compression ignition or diesel engine, *Fig.* 5, compression of air without heat loss occurs as in the Otto cycle, *A* to *B*. Compression ratio is high enough to heat the air above the ignition temperature of the fuel used. Fuel burns as it is injected and therefore, even ideally, heat addition cannot be entirely at constant volume. The old theoretical Diesel cycle assumed that all heat was added at constant pressure. In modern diesel engines heat is added partly at constant volume and partly during the early part of the expansion stroke, approximately at constant pressure. The ideal cycle with which the modern diesel engine should be compared has a pressure-volume diagram as shown in *Fig.* 5. Theoretical calculations for this cycle are highly involved and have little practical significance. For present purposes, the ideal efficiency of a diesel engine may be assumed to follow the curve of *Fig.* 3 at light loads. As load is increased more heat is added during the expansion stroke so that the effective expansion ratio is less than the compression ratio, and the ideal efficiency correspondingly less.

Fundamental Definitions

Power: Power output of an engine is expressed either as *indicated horsepower* or *brake horsepower*. Indicated horsepower (ihp) is the power developed in the cylinders, while brake horsepower (bhp) is the power available from the crankshaft. In large, slow-running engines the ihp can be computed from the area of an indicator card which looks like *Fig.* 2. Since it is difficult to obtain an accurate indicator diagram for engines operating at more than a few hundred rpm, usual procedure for determining ihp is to first determine bhp, using a dynamometer or brake, and then add friction horsepower (fhp) which is determined by "motoring" the engine and measuring the power absorbed. Principal significance of ihp is in calculating effects of atmospheric pressure and temperature.

Efficiency: Actual thermal efficiency of an engine is the ratio of heat of engine output to heat in the fuel consumed. Experimentally, brake thermal efficiency is found by measuring the amount of work actually delivered by the crankshaft over a period of time and dividing

this figure by the work equivalent of the heat content of the fuel consumed in the same time.

Mean Effective Pressure: That hypothetical pressure which, if maintained, throughout the power stroke, would do the same amount of work as the cycle or engine being considered, is known as the mean effective pressure (mep). In a four-cycle engine,

$$p_{me} = \frac{P \times 33{,}000}{\frac{n}{2} LAN}$$

where L is length of stroke, feet; A is cylinder cross section area, square inches; N is the number of cylinders in the engine; and n is the speed rpm. Another convenient form of this equation is

$$p_{me} = \frac{P \times 792{,}000}{nD}$$

where D is piston displacement, cubic inches. For a two-cycle engine

$$p_{me} = \frac{P \times 396{,}000}{nD}$$

since there are twice as many power strokes. Indicated mean effective pressure (imep) and brake mean effective pressure (bmep) may be calculated from these formulae by substituting ihp or bhp for hp. Mean effective pressure can be a useful quantity when comparing engines of different sizes since it eliminates the factors of engine displacement and speed. The fact that mep is directly proportional to torque per cubic inch of piston displacement may also serve to explain the significance of this quantity. Unless otherwise specified, mep of an engine is calculated using maximum horsepower and the rpm at which it is developed.

Specific Fuel Consumption: Fuel economy or consumption of an engine is generally expressed as specific fuel consumption (sfc). Dimensions of this quantity are pounds of fuel per horsepower-hour. The abbreviations bsfc or isfc are usually used and indicate whether the quantity relates to consumption per brake or indicated horsepower-hour.

Volumetric Efficiency: One of the most important factors limiting power output of an engine is the amount of air which it can consume. This is true because only a certain amount of fuel can be burned with a given amount of air and while fuel flow can be easily increased, air flow cannot be increased beyond the capacity of the cylinders. Piston displacement multiplied by rpm of a two-stroke engine is the maximum air flow rate. For a four-cycle engine the maximum rate would be half this product. Volumetric efficiency is defined as the ratio of actual air flow to this maximum quantity. For a four-cycle engine

$$E_v = \frac{Q}{\left(\frac{n}{2}\right)\left(\frac{D}{1728}\right)}$$

where Q is air flow, cubic feet per minute. In a well-designed engine, volumetric efficiency is usually between 75 and 90 per cent. Exhaust gas dilution, heating during intake, valve restriction, and other factors affect volumetric efficiency unfavorably. Supercharging can increase volumetric efficiency well above 100 per cent.

Engine Characteristics

For any application the ideal engine is the smallest, lightest, least expensive, most dependable, most easily serviced, quietest one having the required power output and consuming the least amount of the cheapest fuel. Engines combining all these qualities are not available, and it is necessary to sacrifice one or more desirable attributes to gain one or more others.

Because this is so, it will be necessary to confine discussion to the recognizable advantages and disadvantages of types of construction used in commercially available engines. Those using spark ignition and gasoline for fuel will be discussed in this article. Since spark ignition engines using fuels other than gasoline share the characteristics of gasoline engines, no specific dicussion of these engines will be included. Diesel engines will be discussed in the concluding portion of the article.

Gasoline Engines

General: Certain advantages are inherent with the use of gasoline for fuel. First is the wide availability of gasoline. Another is the relative simplicity of the fuel induction system which helps to keep cost down and simplify servicing and maintenance. Comparative smoothness of operation can also be claimed for gasoline engines, except when detonation occurs, because the combustion pressures are moderate. This characteristic also tends to reduce size and weight of gasoline engines because smaller, lighter parts can be used.

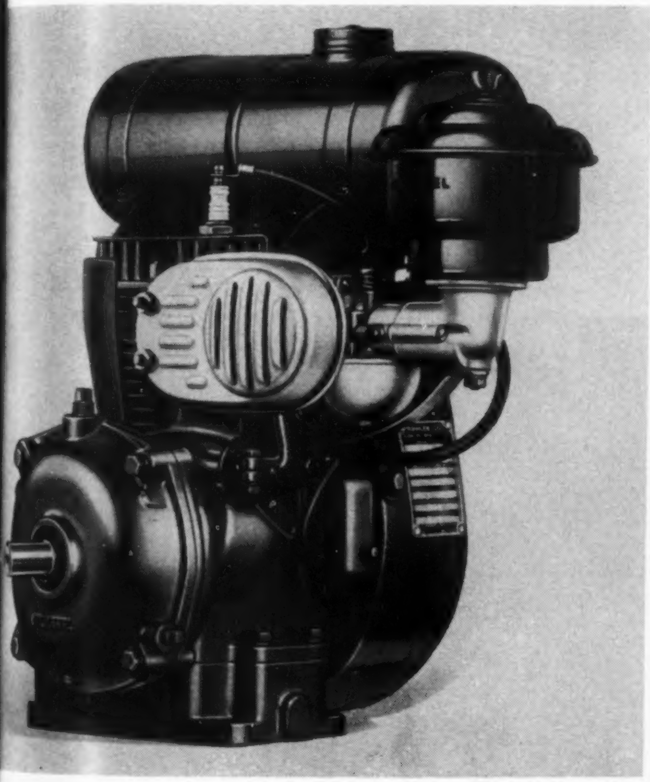
Possible disadvantages of the gasoline-fueled engine must be recognized since certain of them must be reckoned with when installing the engine as well as in selection. Gasoline is flammable and, when mixed with air in the proper

proportion, explosive. However, this is no particular hazard if reasonable care is used in handling. Exhaust fumes from gasoline engines especially when operating with a rich mixture or poor combustion contain carbon monoxide which is deadly to human beings. Again, proper precautions such as gas-tight ducts to vent the fumes to the atmosphere eliminate the danger. Catalytic devices to convert the carbon monoxide into harmless gases may also be used to eliminate the possibility of exhaust gas poisoning. Other possible drawbacks are cost

of the fuel and a thermal efficiency which is limited by the moderate compression ratios that must be used to avoid pre-ignition.

In analyzing the commercially available types of gasoline engines, three separate and distinct groups are found. These are:

1. General purpose air-cooled engines
2. General purpose water-cooled engines
3. Special-purpose engines



General Purpose Air-Cooled Engines: With notable exceptions, all the engines in this group have piston displacements of 154 cubic inches or less and develop less than 40 horsepower. The exceptions are a large 6-cylinder opposed engine having a piston displacement of 895 cubic inches and developing 375 and 500 horsepower in its non-supercharged and supercharged versions respectively and a V-12 of 1790 cubic inch displacement developing 810 horsepower. Discussion will be confined to the smaller engines for this reason.

Many of the engines in this group are one-cylinder, four-cycle types, of which *Fig.* 6 shows a typical example. Also included are one and two-cylinder two-cycle engines, *Fig.* 7; two and four-cylinder, four-cycle engines, *Fig.* 8.

Maximum horsepower developed by single-cylinder engines of this group varies from one to ten. Two and four-cylinder engines have outputs ranging from 1.15 to 36 horsepower. Speed at which maximum horsepower is developed is generally within the range of 3000 to 3600 rpm, although some two-cycle engines may develop highest power at speeds as high as 6500

Fig. 6—Above—Typical small, one-cylinder, air-cooled, four-cycle gasoline engine has piston displacement of 8.86 cubic inches, develops 3.6 horsepower at 3000 rpm and weighs 52 pounds. This particular model incorporates a 6 to 1 gear reducer for applications requiring low power-take-off speeds

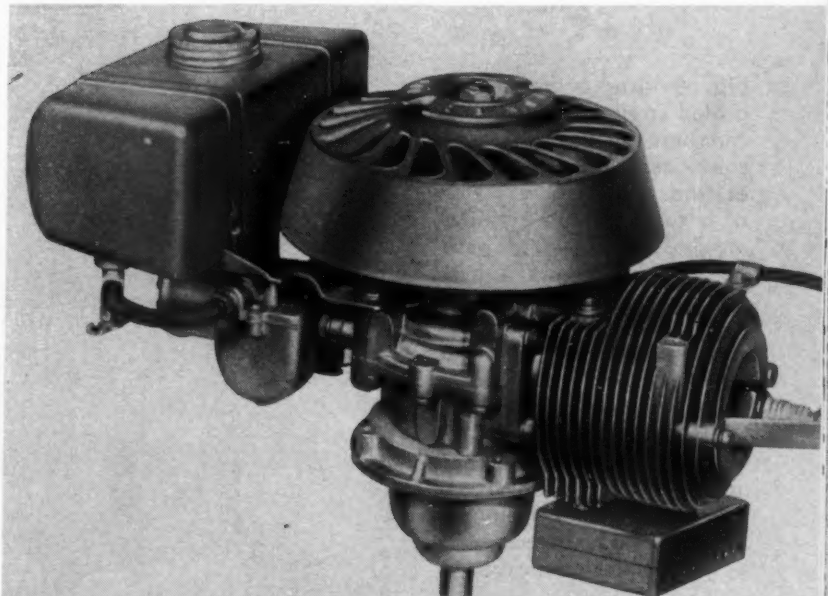


Fig. 7—Right—Small one-cylinder, two-cycle, air-cooled engine develops two horsepower and weighs 13 pounds. Designed to operate with the crankshaft in a vertical plane, the engine measures 11 inches high, 8½ inches wide and 14½ inches long including fuel tank, blower, carburetor and other accessories

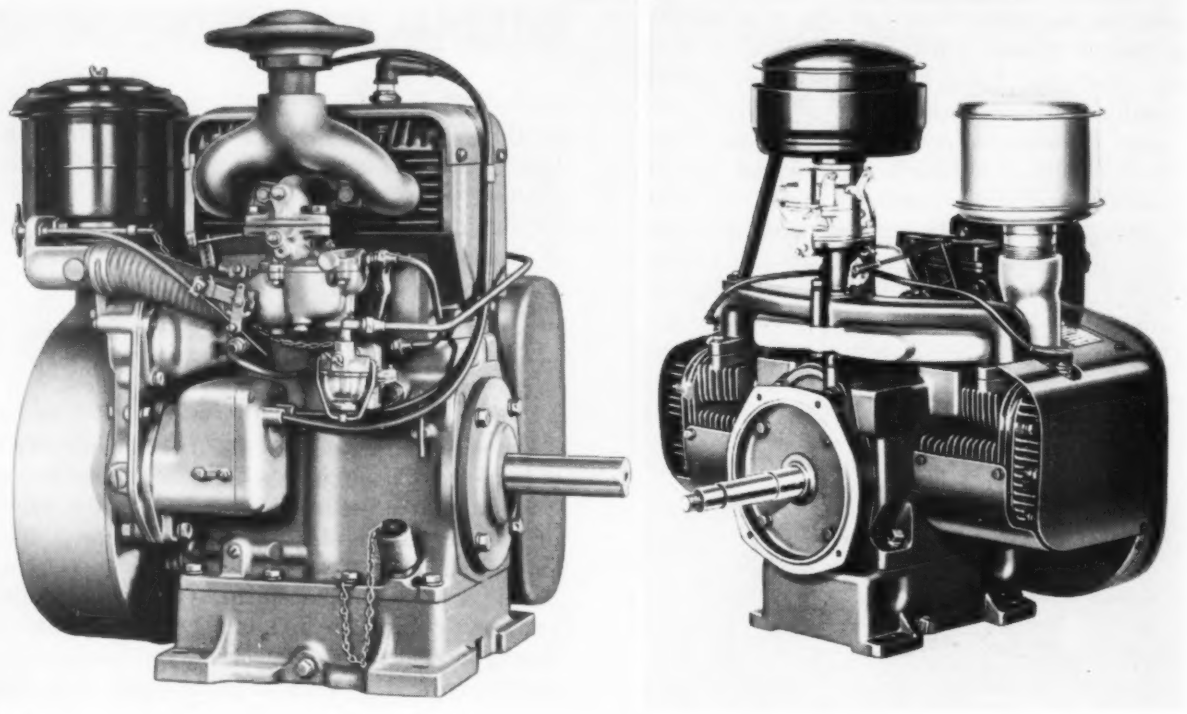


Fig. 8—Above—Two-cylinder, air-cooled engines may have in-line, left, or opposed-cylinder arrangement, right. This in-line engine is a four-cycle type developing 14.3 horsepower at 2600 rpm; maximum torque is 32.4 lb-ft developed at 1600 rpm. Weight of the engine is 220 pounds; length is 22 5/16 inches; width is 21 11/16 inches; height is 25 9/16 inches. Opposed cylinder engine develops 26.8 horsepower at 3600 rpm. Weight is 225 pounds. Length, width and height are 22½, 23⅛ and 27 9/16 inches respectively

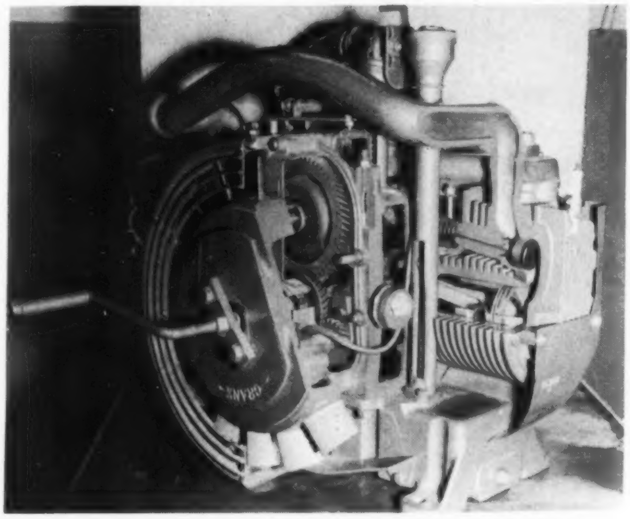


Fig. 10 — Above — Hand crank is used to start this two-cylinder opposed type engine. Blades cast as integral part of flywheel draw cooling air over finned surfaces of the engine. Maximum horsepower developed by this engine is 10.1. Weight is 97 pounds. Height is 19 inches, width is 19¾ inches and length is 19⅜ inches

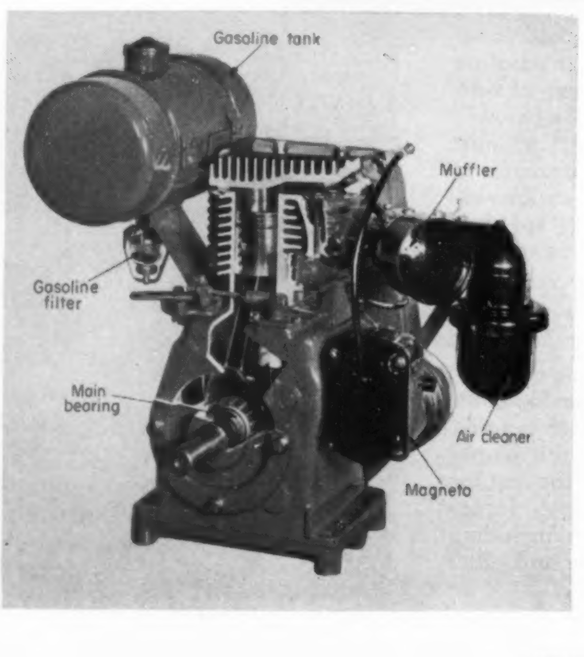


Fig. 9—Right—Small air-cooled engines are ready-to-run units incorporating all components necessary to operation. This cutaway view of a typical single-cylinder, air-cooled four-cycle gasoline engine shows L-head valve arrangement and cooling fins. Developing a maximum of 6.2 hp at 3600 rpm, the engine weighs 76 lb and is 20⅛ inches wide across muffler and gas tank, 19 inches from bottom of base to top of tank filler cap and 14 19/32 inches from end of crankshaft extension to rope starter sheave

Fig. 11—Above—Rewind-type starter obviates need for rewinding starting rope, if an engine fails to start on the first attempt. This $3\frac{1}{2}$ horsepower, two-cycle, air-cooled engine weighs 26 pounds and measures 14 3/16 inches long, 12 5/16 inches wide and 13 9/16 inches high

Fig. 12—Below—Schematic diagrams show magneto ignition system, *a*, battery ignition system, *b*, and output characteristics of the two, *c*. Dotted line in *c* represents normal characteristic of magneto ignition system which would make starting difficult, if not impossible. An impulse coupling which is essentially a spring and pawl mechanism, drives the magneto at many times engine speed to facilitate starting and modify magneto output as shown

rpm. Certain of the multicylinder engines and engines designed for driving electric generators develop maximum power at speeds of 850 to 2600 rpm. Torque output of these engines is from 1.4 to 94 lb-ft at speeds from 600 to 5000 rpm.

Usually engines in this group are supplied as a complete power package ready to be mounted and run. Various items such as air cleaner, muffler, gasoline tank, starting means, fuel filter, a complete magneto ignition system and the blower or fan for cooling are all a part of the engine assembly, *Fig.* 9.

Starting methods include hand cranks, *Fig.* 10, ropes, rewind and recoil starters, *Fig.* 11, as well as electric starters. Rope, rewind and recoil types are most widely used. Cranks are generally used with the larger engines. Electric starting is an optional feature on a few engines and is not usually available on many in this low horsepower range, since the engines are small enough to be easily started by hand. Also the addition of a storage battery, starting motor and battery charging generator could more than double the weight of many small engine installations. Weight of the electrical starting system also dictates the use of the magneto, *Fig.* 12*a,* rather than the battery ignition system, *Fig.* 12*b*. Weights of engines in this group fall within a range of 7 to 20 pounds per horsepower.

Generally small engines are designed to operate with the axis of the crankshaft in a horizontal plane with the axis of the cylinder or cyliners in either a vertical or horizontal plane. There are variations in which the engine may

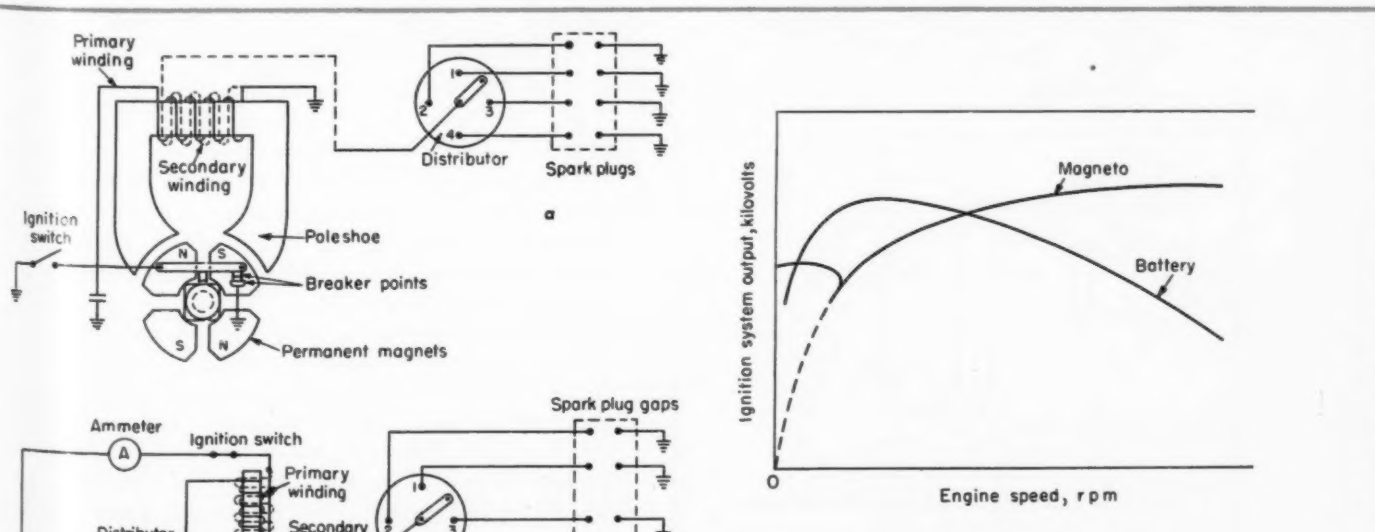
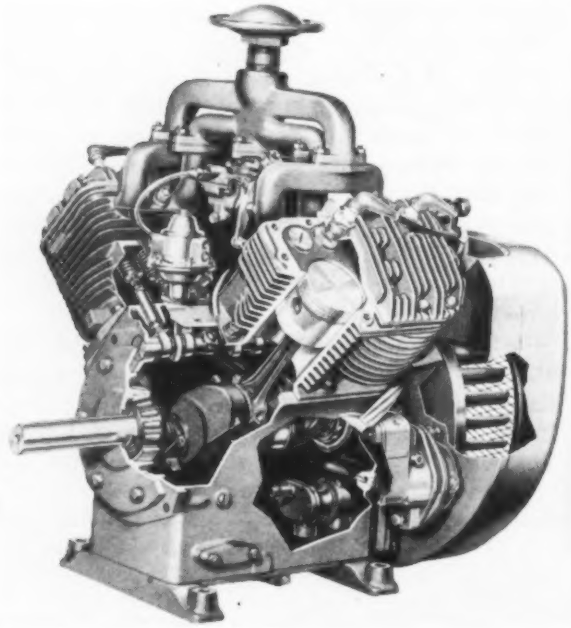
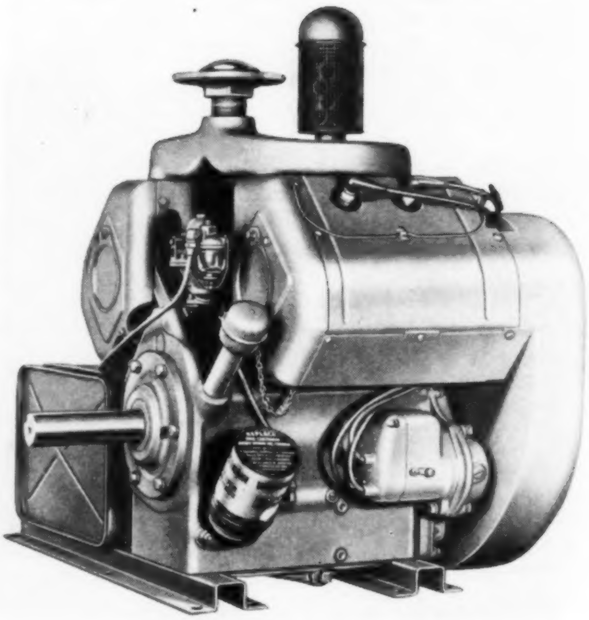


Fig. 13—Right—Vertical shaft engine has piston displacement of 6.207 cubic inches and develops 2 horsepower at 3600 rpm. Maximum torque is 3.05 lb-ft at 3200 rpm. Extensive use of aluminum alloys has kept weight of this four-cycle engine down to $19\frac{1}{2}$ pounds. The engine is $12\frac{7}{8}$ by $10\frac{7}{8}$ by 9 25/32 inches high excluding shaft extension

Fig. 14—Below—Vee type, four cylinder engine is shown cutaway with shrouds removed, left, and with cooling shrouds in place, right. Weighing 440 pounds complete with gas tank, the engine develops 36 horsepower at 2200 rpm and torque of 93 lb-ft at 1500 rpm





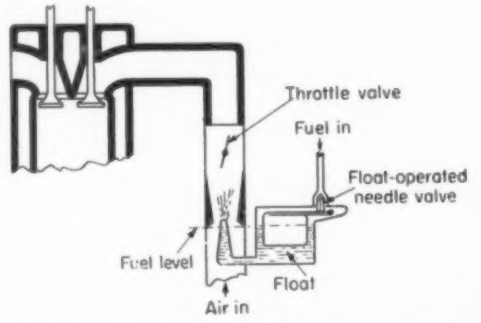


Fig. 15—Float-type carburetors commonly used in four-cycle gasoline engine fuel induction systems require that gasoline in the float chamber be held at a fixed level for proper fuel metering

be operated with the crankshaft axis in a vertical plane, *Figs.* 7 and 13. Cylinders are in some instances inclined at an angle of 20 degrees above horizontal. Vee types, of course, also have inclined cylinders, *Fig.* 14.

Because of the fuel system, *Fig.* 15, and lubricating oil sump, four-cycle engines ordinarily cannot be operated when tilted more than 30 degrees from their normal position. Lubrication and fuel induction systems of two-cycle engines permit them to be operated in any position. Fuel and lubricating oil are mixed together in these engines and the mixture passed through the crankcase of the engine, *Fig.* 16, thus lubricating the moving parts.

Power take-off ends of crankshafts, or crank-

shaft extensions as they are often called, vary considerably in size because of differences in torque output of the engines. Several crankshaft extension arrangements, *Fig.* 17, are usually available at the option of the user to permit mounting of sheaves, clutches or couplings. Engine assemblies incorporating speed reducers, *Fig.* 6, clutches, *Fig.* 18, or both, are also available.

INTERNAL COMBUSTION ENGINES

General Purpose Water-Cooled Engines: With few exceptions, this group consists of multicylinder in line, *Fig.* 19, or vee-type, *Fig.* 20, engines. Because of their use in automotive vehicles more engines of this type are manufactured

Fig. 16—Three types of fuel induction systems are commonly used with two-cycle gasoline engines. In all cases the combustible mixture contains lubricating oil in the proportion of approximately one pint per gallon of liquid gasoline. This serves to lubricate the engine and eliminates the need for an oil reservoir. Oil consumption is, of course, greater than for four-cycle engines

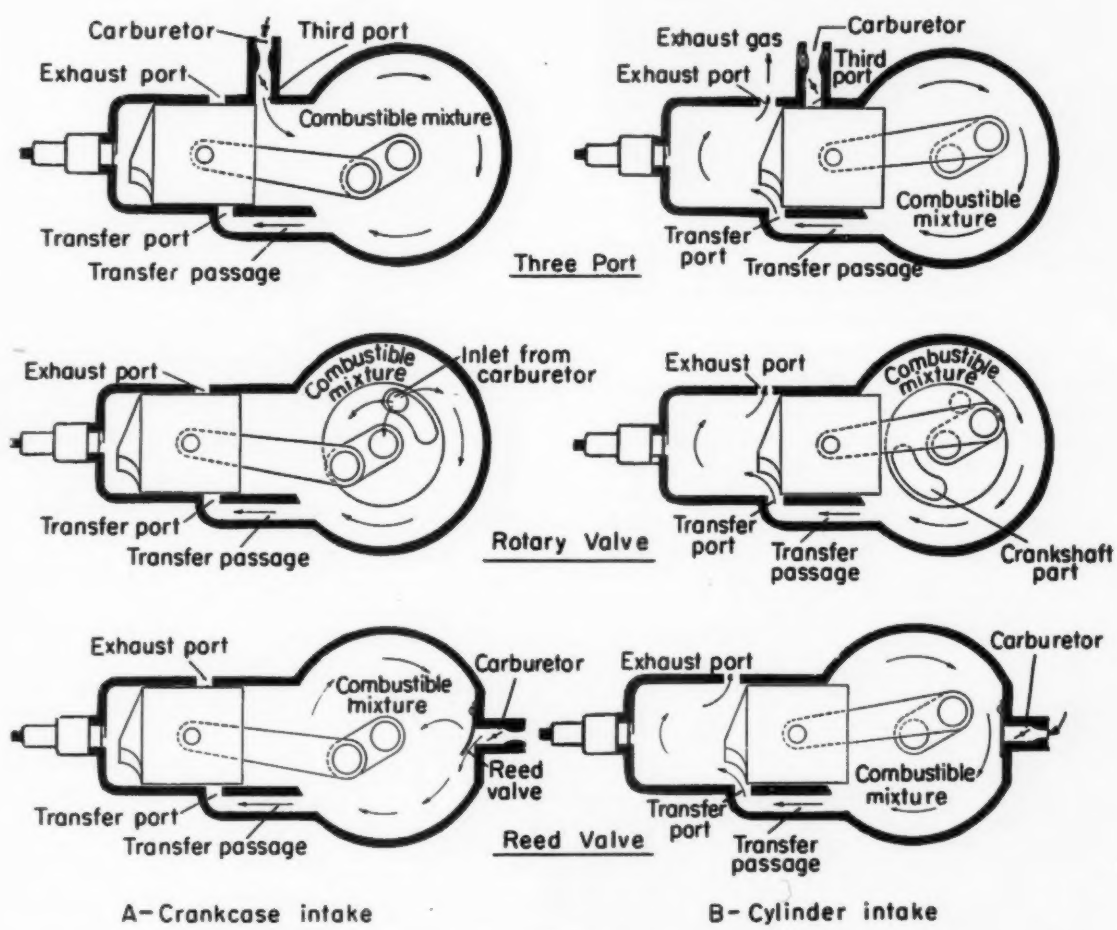
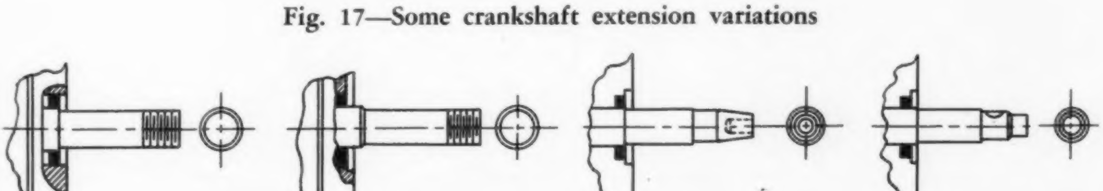


Fig. 17—Some crankshaft extension variations



and used than all other types combined.

Maximum horsepower outputs range from 3 to 700, however, most of these engines are in the 50 to 200-horsepower class. When higher power than available from a single engine is required, multiple units can be used, *Fig.* 21. Speeds at which maximum horsepowers are developed vary from 1000 to 4200 rpm. Although the largest engines (over 300 horsepower) usually develop maximum horsepower at speeds less than 2000 rpm, no other generalization regarding horsepower and speed can be made. Because horsepower peak is a function of piston speed rather than rpm, larger engines develop their maximum horsepower at lower crankshaft speeds.

Torque outputs vary from approximately 18 to 3300 lb-ft at speeds ranging from 650 to 3000 rpm. However, 90 per cent or more of these engines develop maximum torque at speeds between 1000 and 2000 rpm. As with horsepower, torque relationships depend upon piston speed, valve size, valve timing and other factors that

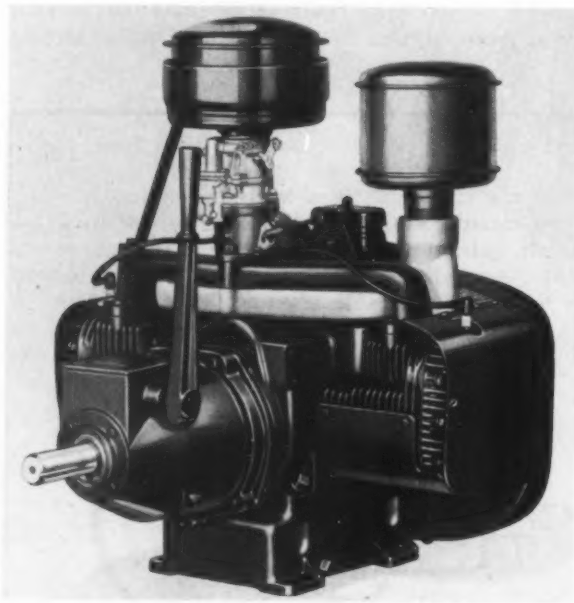
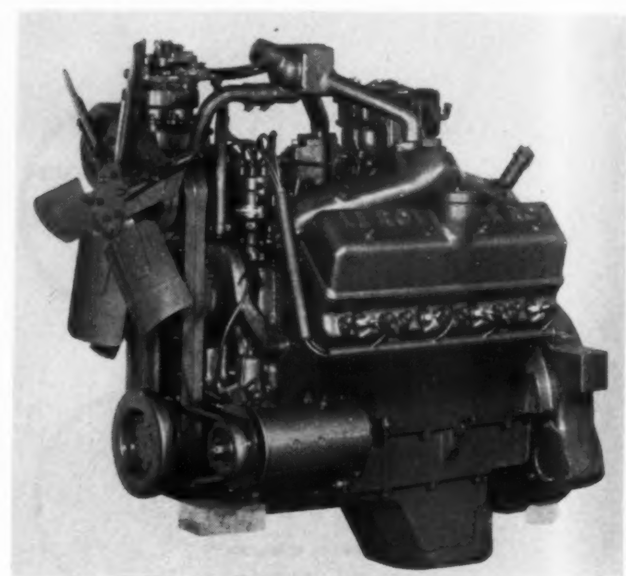


Fig. 18—Above—Two cylinder opposed type engine of *Fig.* 7 is fitted with wet-type, hand-operated clutch

Fig. 19—Below—Six-cylinder, in-line, water-cooled engine has displacement of 855 cubic inches, develops maximum horsepower of 265 at 2400 rpm and maximum torque of 680 lb-ft at 1400 rpm. Dry weight of bare engine is 2150 pounds. Overhead valves are used. Cylinders are cast en bloc



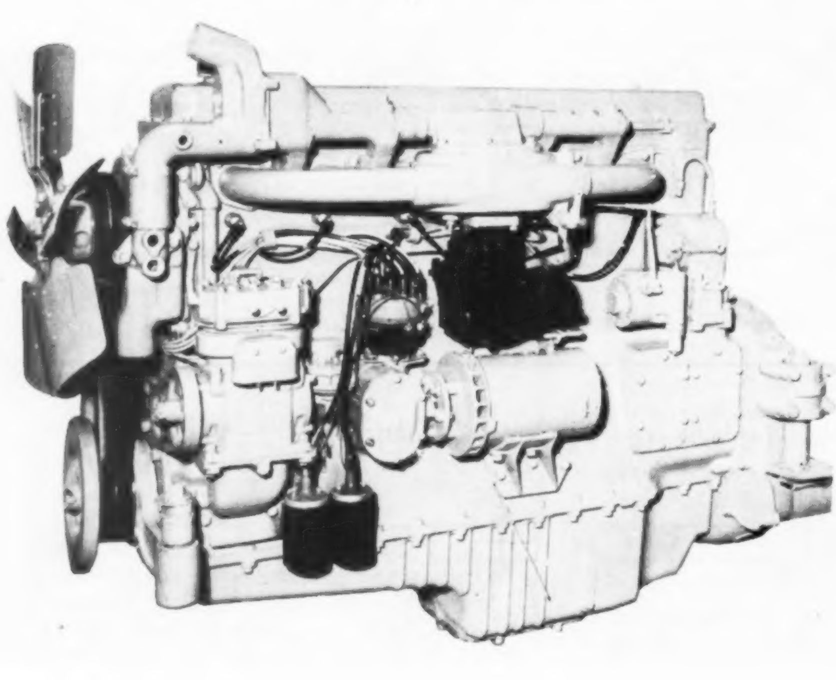


Fig. 20 — Above — Heavy - duty, water - cooled, Vee-type eight-cylinder engine displaces 540 cubic inches, develops 207 horsepower at 3000 rpm and has maximum torque rating of 450 lb-ft at 1800 rpm. Weight is 1250 pounds

affect volumetric efficiency.

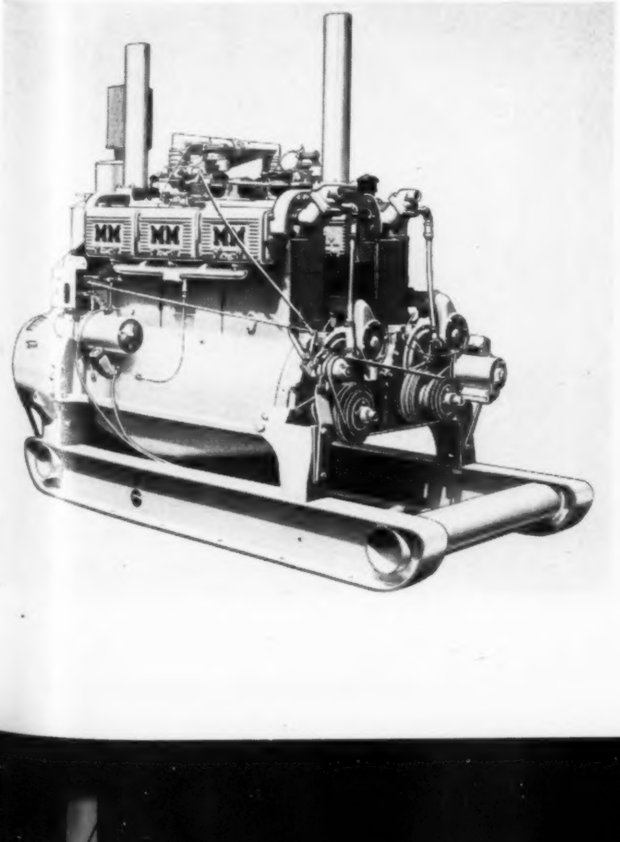
Weight to horsepower ratios vary from 5 to over 300 pounds per horsepower for dry engine units. Although the lower figure given seems somewhat incongruous when compared to weight/horsepower ratios of small air-cooled engines with their inherently lighter construction, there is an explanation. Weights of these larger liquid cooled engines do not include various items such as fuel tanks, coolant, coolant radiators, ignition system including battery and other items which are necessary to a complete ready-to-run assembly. Additionally, the weight of many of these accessory items is relatively constant regardless of engine size and therefore, may constitute a relatively large portion of total engine installation weight on the smaller engines.

Three general types of cylinder construction are used in water-cooled engines. They are:

1. Cast en bloc, *Fig.* 22, in which the cylinder is bored in the cylinder block casting.
2. Dry sleeve, in which a cylindrical sleeve is fitted into a bored hole in the cylinder block casting.
3. Wet sleeve, *Fig.* 23, where the sleeve is retained in the block casting only at or near its upper and lower ends and is in direct contact with the cooling liquid.

Cylinder types are listed in order of decreasing ease of manufacture and increasing cost. Sleeves, of course, simplify reconditioning of cylinder bores and wet sleeves are generally con-

Fig. 21—Two six-cylinder engines mounted on the same base and geared to a single power take-off shaft are used to provide higher power when necessary. As many as four engines have been used together in a similar manner



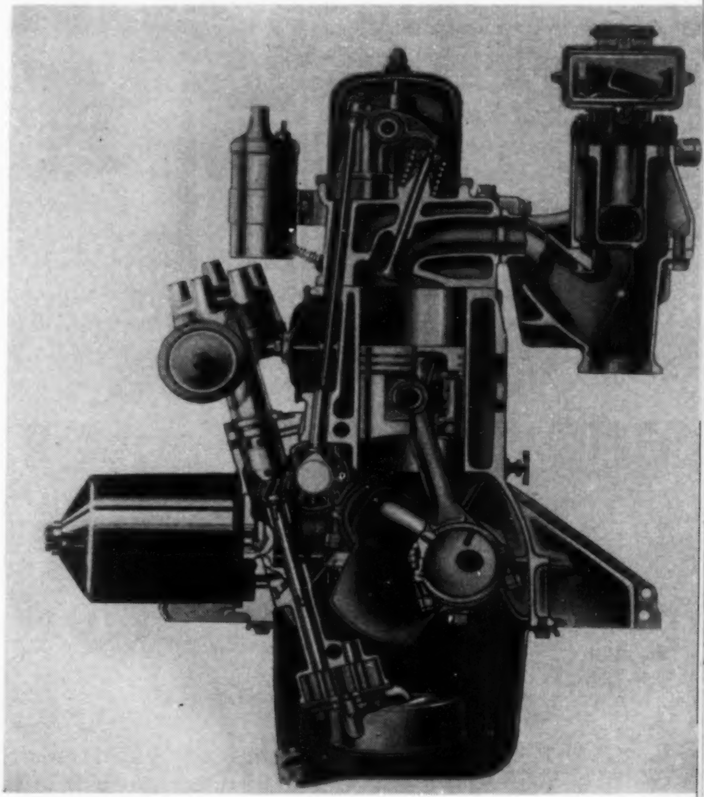
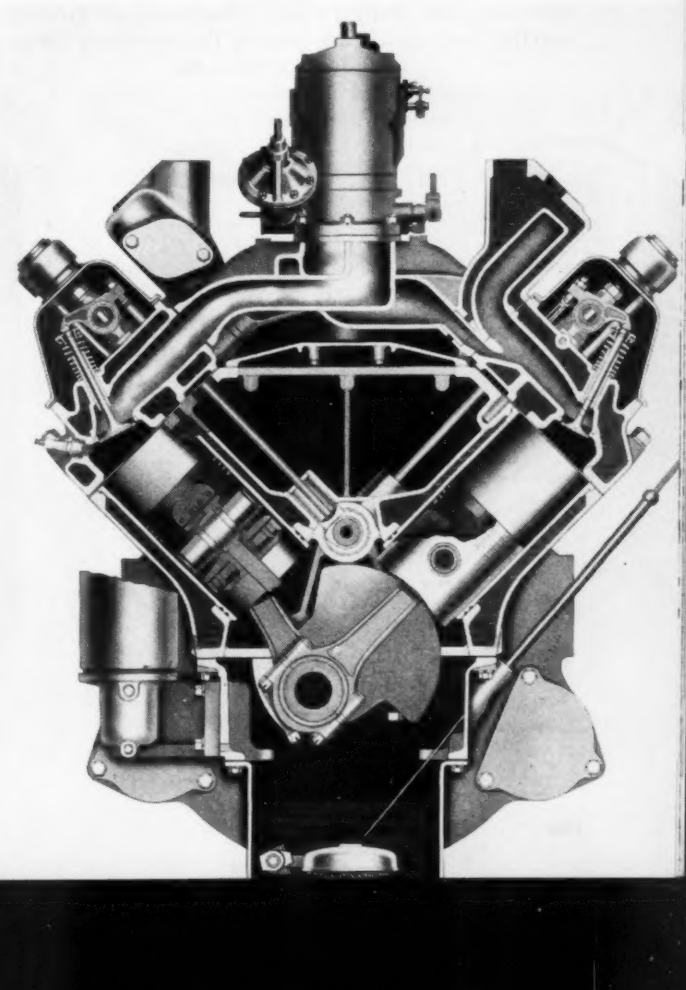
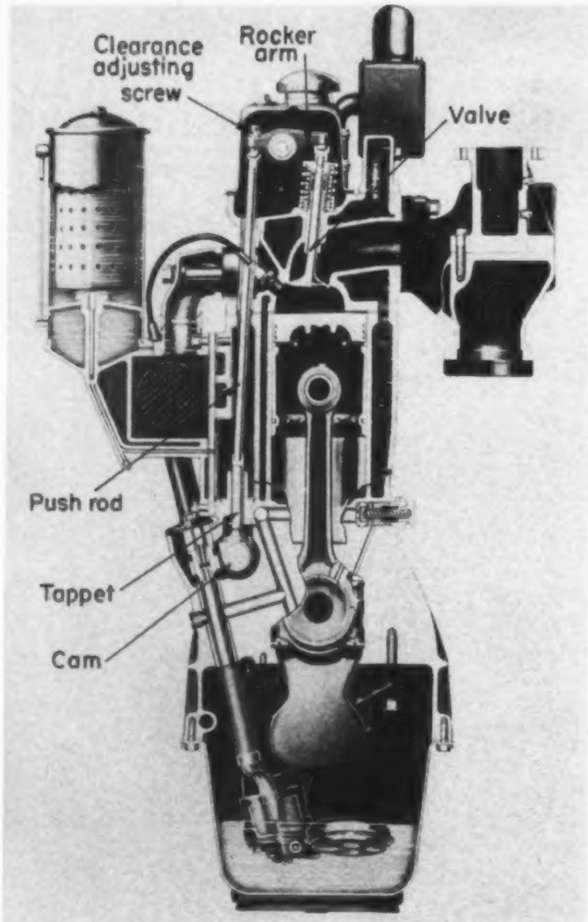


Fig. 22—Cutaway view shows engine with cast en bloc cylinders

Fig. 23—Cylinders of this V-8 engine are wet-sleeve type and are retained in the block casting only near the top and bottom





ceded to be least liable to distortion and give most uniform cylinder cooling. All three types of cylinders have proven themselves satisfactory in a variety of applications.

Valve arrangements include the L-head or side-valve arrangement, *Fig.* 9, where the valve seats are in the cylinder block at the side of cylinder, or overhead valves, *Fig.* 24, where valves are in the cylinder head. Less commonly used is the F-head valve system in which the intake valve is in the head and the exhaust valve is in the block, *Fig.* 25.

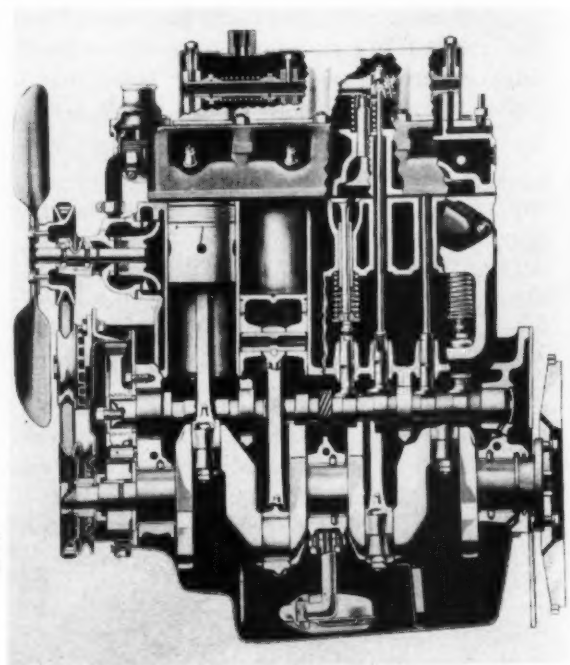
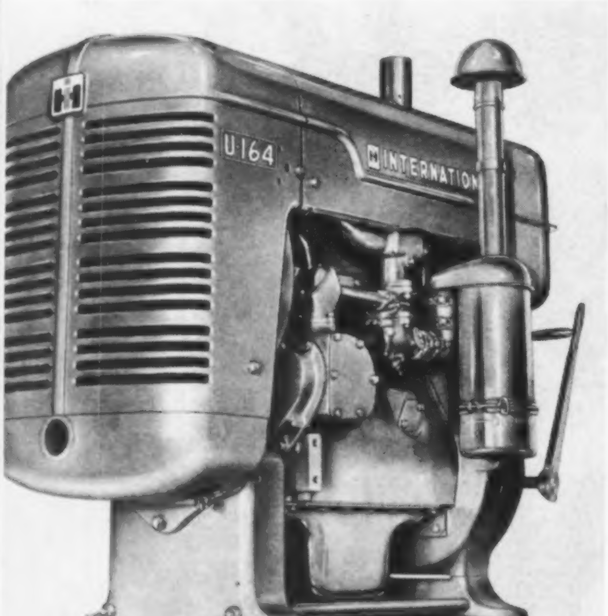


Fig. 24—Above—Valve-in-head system requires push rod, rocker arm and rocker arm shaft in addition to parts in L-head system

Fig. 25—Right—F-head combines qualities of L-head and valve-in-head systems. Intake valves are in head, exhaust valves in block

Fig. 26—Below—Semi-enclosed engine unit is complete and ready to run. Radiator, air cleaner muffler and clutch are among the accessory items included in this unit

Fig. 27—Below—Completely enclosed engine unit includes all necessary accessory items



Least expensive to manufacture is the L-head because fewer parts are required. On the other hand, valves cannot be made as large for a given cylinder bore size in an L-head engine as they may be in either the overhead or F-head. Valve size and location can have a pronounced effect on volumetric efficiency. The path followed by both intake and exhaust gases tends to be somewhat more devious in the L-head engine than in the overhead-valve type.

Servicing of the valve systems of overhead-valve engines is generally considered to be somewhat simpler because the adjustment for valve-train clearance is more easily accessible than in the L-head. Servicing is also facilitated by overhead valves because the head may be removed from the engine and taken to a workbench or other workplace for valve seat resurfacing. This feature can be extremely important where downtime must be avoided since a spare cylinder head assembly can be quickly interchanged with that on the engine when valve seats need reconditioning.

Insofar as dependability is concerned, none of the three valve arrangements possesses any inherent advantages. Valve and valve-seat life may be prolonged with any of the systems by using special alloys for valves or facings of the seating surface, valve seat inserts in head or block, and systems to cause slow rotation of the valves while operating. It has been estimated that by using a facing on the valve head plus valve rotation, valve life may be lengthened as much as ten times. Perhaps worthy of mention is the fact that for equal bore and stroke, an L-head engine will usually be somewhat wider and lower than the overhead.

Piston rings are a very important part of any engine. Recent years have seen the introduction of many piston ring coatings such as tin and chromium which reduce both piston ring and cylinder wall wear. Many commercially available engines are fitted with piston rings using such coatings. Use of chrome-plated rings in heavy-duty engines is almost universal.

Any of the engines in this group may usually be procured from the manufacturer with little or none of the required equipment such as radiator, clutch, carburetor, etc., or as a complete ready-to-run unit, *Fig.* 26, some including even a sheet metal enclosure, *Fig.* 27. Power-take-off is commonly from the flywheel end of the engine through a friction clutch. Clutch output shafts of various types for mounting pulleys, sheaves or couplings may be supplied. Torque converters or fluid couplings may also be engine mounted.

Special-purpose Engines: Marine, automotive and aircraft engines make up this group. Gasoline fueled marine engines are nearly identical with the general purpose water-cooled types insofar as construction of the basic engine unit is concerned. Outputs cover a range of 5 to 700 horsepower. Major difference is usually in accessory items and their arrangement, *Fig.* 28. For instance, power-take-off is rarely from the flywheel end of the engine.

Another variation resulting from the use of lake or sea water as a coolant is the use of water jacketed exhaust manifolds to preheat the water before it enters the engine block. This is not necessary, of course, when a fresh water-sea water heat exchanger is used. Cooling water is recirculated through the engine and does not reach temperatures as low as the sea water.

Both reverse gears and reduction gears are

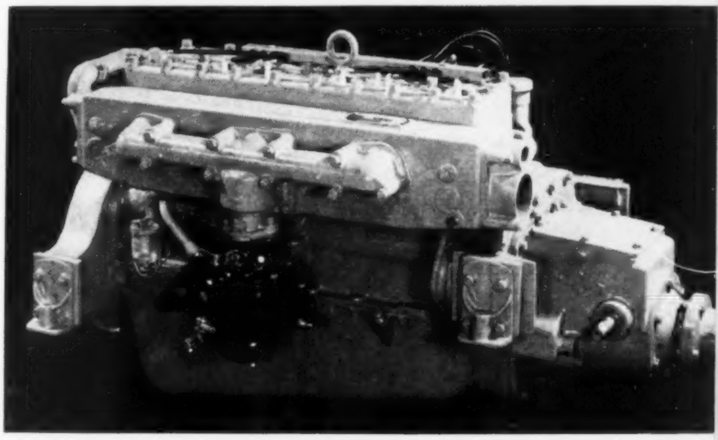
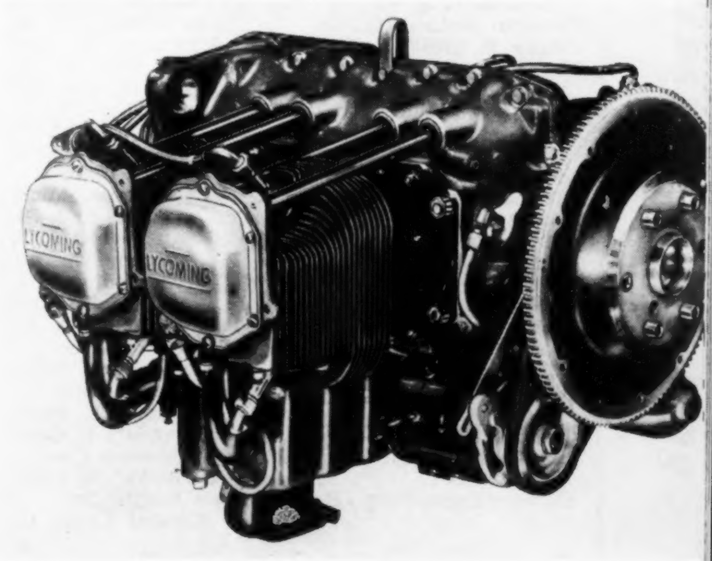


Fig. 28—Above—Representative marine engine has water-cooled manifolds, reversing gear and may be fitted with reduction gearing. Horsepower developed by this engine is 130 at 3000 rpm. Maximum torque is 239 lb-ft at 2400-2500 rpm. Dry weight is 850 pounds

Fig. 29—Below—Opposed-type, four-cylinder air-cooled aircraft engine has piston displacement of 320 cubic inches and develops 150 horse-power at 2700 rpm. Dry weight is 272 pounds



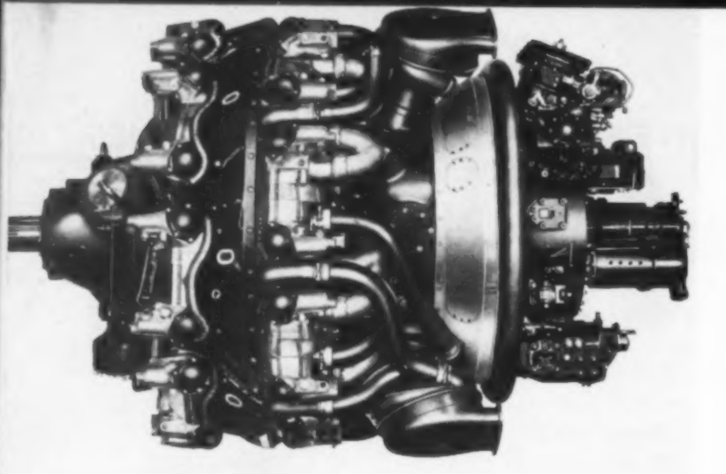


Fig. 30—Two-row, 18-cylinder, radial aircraft engine has piston displacement of 3350 cubic inches and develops 3250 horsepower at 2900 rpm. Weight is 3484 pounds. Three exhaust driven turbines are used to recover energy from the exhaust gases and transmit it to the crankshaft. Two of the turbines are visible, one at the top and one at the bottom of this photo

usually supplied by marine engine manufacturers as part of the engine assembly. Use of reduction gears is dictated by boat and propeller size and engine rpm in many instances since propeller efficiency falls off rapidly at high rpm. Some boats use reversible-pitch propellers, which obviates the need for a reversing gear.

Reciprocating aircraft engines produced in this country are almost if not altogether without exception air-cooled types using opposed, *Fig.* 29, or radial, *Fig.* 30, cylinder arrangements. Reason for this virtual monopolization of the aircraft engine field by air-cooled engines is the lower ratio of weight to power which is inherent in air-cooled types. The inherent lightness of the air-cooled engine combined with careful design for weight reduction have resulted in the production of engines producing almost one horsepower for each pound of weight. Highest weight per horsepower ratio of presently produced engines is 2.85 lb per hp.

Outputs of aircraft engines range from 65 horsepower for a small four-cylinder engine to 3500 horsepower for a large, 28-cylinder radial engine. Horsepower outputs of this order are obtained by using superchargers, high octane gasolines and in some instances exhaust turbines which absorb energy from the exhaust gases and deliver this energy to the crankshaft, *Fig.* 30. Measures such as this to obtain high horsepower to weight ratios are, of course, expensive and can usually only be justified in aircraft where it is estimated that three pounds of airframe can be eliminated for each pound of engine weight reduction.

Part 2 of this article, to appear in a future issue, will consider available types of diesel engines. Also, the factors to be considered in selecting all types of engines will be covered.

ACKNOWLEDGEMENT

MACHINE DESIGN acknowledges with appreciation the co-operation of these companies in the preparation of this, and the concluding part of this article.

Allis-Chalmers Mfg. Co., Tractor Div. .... Milwaukee 1, Wis.
Baldwin-Lima-Hamilton Corp. .. Philadelphia 42, Pa.
Berry-Hill Corp., Hill Diesel Engine Div. .... Providence 5, R. I.
Blackie & Son Ltd., Publishers, *The High-Speed Internal Combustion Engine*, by Sir Harry R. Ricardo (Fig. 4) .... London, England
Brennan Motor Mfg. Co. .... Syracuse 2, N. Y.
Briggs & Stratton Corp. .... Milwaukee 1, Wis.
The Buda Co. .... Harvey, Ill.
Caterpillar Tractor Co. .... Peoria, Ill.
Chesapeake and Ohio Railway Co. (Fig. 1) .... Cleveland, O
Chris-Craft Corp. (Fig. 28) .... Algonac, Mich.
Chrysler Corp., Marine and Industrial Engine Div. (Fig. 27) .... Trenton, Mich.
Climax Engine & Pump Mfg. Co. .... Chicago 4, Ill.
Continental Motors Corp. (Fig. 24) Muskegon, Mich.
Cummins Engine Co. Inc. .... Columbus, Ind.
Curtiss-Wright Corp. (Fig. 30) .. Wood-Ridge, N. J.
Cushman Motor Works Inc. .... Lincoln, Neb.
Fairbanks, Morse & Co. .... Chicago 5, Ill.
Ford Motor Co., Tractor & Industrial Engine Div. (Fig. 22) .... Highland Park, Mich.
General Motors Corp., Detroit Diesel Engine Div. .... Detroit 28, Mich.
Gladden Products Corp. .... Glendale 4, Calif.
Hall Scott Motor Div., ACF-Brill Motors Co. (Fig. 19) .... Berkeley 10, Calif.
Harnischfeger Corp., P. & H Diesel Engine Div. .... Crystal Lake, Ill.
Hercules Motors Corp. .... Canton 2, O.
Homelite Corp. .... Port Chester, N. Y.
International Harvester Co. (Fig. 26) Chicago 1, Ill.
Jacobs Aircraft Engine Co. .... Pottstown, Pa.
Kermath Mfg. Co. .... Detroit 8, Mich.
Kohler Co. (Figs. 6, 8b, 18) .... Kohler, Wis.
The Lauson Co., Div. Hart-Carter Co. (Fig. 13) .... New Holstein, Wis.
Le Roi Co. (Figs. 20, 23) .... Milwaukee 14, Wis.
Lycoming Div., Avco Mfg. Corp. (Fig. 29) .... Williamsport, Pa
McCulloch Motors Corp. (Fig. 1) .... Los Angeles 45, Calif.
Minneapolis-Moline Co. (Figs. 1, 21) .... Minneapolis 1, Minn.
Nordberg Mfg. Co. .... Milwaukee, Wis.
The Oliver Corp. .... Chicago 6, Ill.
D. W. Onan & Sons Inc. (Fig. 10) .... Minneapolis 14, Minn.
Power Products Corp. (Figs. 7, 11, 16) Grafton, Wis.
Pratt & Whitney Aircraft, Div. United Aircraft Corp. .... East Hartford 8, Conn.
Scott-Atwater Mfg. Co. Inc. (Fig. 1) .... Minneapolis 13, Minn.
R. H. Sheppard Co. Inc. .... Hanover, Pa.
Universal Motor Co. .... Oshkosh, Wis.
Waukesha Motor Co. .... Waukesha, Wis.
Willys Motors Inc., Industrial Engine Dept. (Fig. 25) .... Toledo, Ohio
Wisconsin Motor Corp. (Figs. 8a, 9, 14) .... Milwaukee 46, Wis.

Determining Stresses in

Pressurized Thin-Wall Tubes

of Near-Circular Cross Section

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FOR THIN-WALLED tubes subject to internal or external fluid pressures, geometry of the cross section has an important influence on the elastic stress distribution pattern. In elliptical or out-of-round tubes, maximum stress will exceed that of the true round shape with stress magnitude dependent on the degree of deviation from a true circular cross section.

This data sheet presents a method for the quick determination of stresses produced by pressure loading in thin-wall elliptical tubes, *Fig.* 1, and in slightly out-of-round circular tubes, which are a particular case of the former. The cross section of a circular tube which is slightly out of round can be closely approximated with an elliptical tube by equating maximum and minimum diameters of the circular tube to major and minor diameters of the elliptical tube. A complete solution to this design problem was presented by Mita*; however, there is no complete English reference. The solution discussed in this data sheet can be applied to out-of-round tubing and other near-circular section shapes encountered in machine hydraulics as well as to tunnels, aircraft structures, submarine structures, and caisson constructions which are of elliptical cross section.

Method of Solution: Stresses produced at any section in a transverse plane of an elliptical tube, *Fig.* 1, are composed of two components: (1) Bending and (2) hoop stresses. Hoop stresses present no problem and can be determined in the usual manner. Thus, the hoop stress at *A Fig.* 1 is

*R. Mayer Mita—*Zeitschrift des Vereines Deutscher Ingenieure*, Vol. 58, 1914, Page 649.

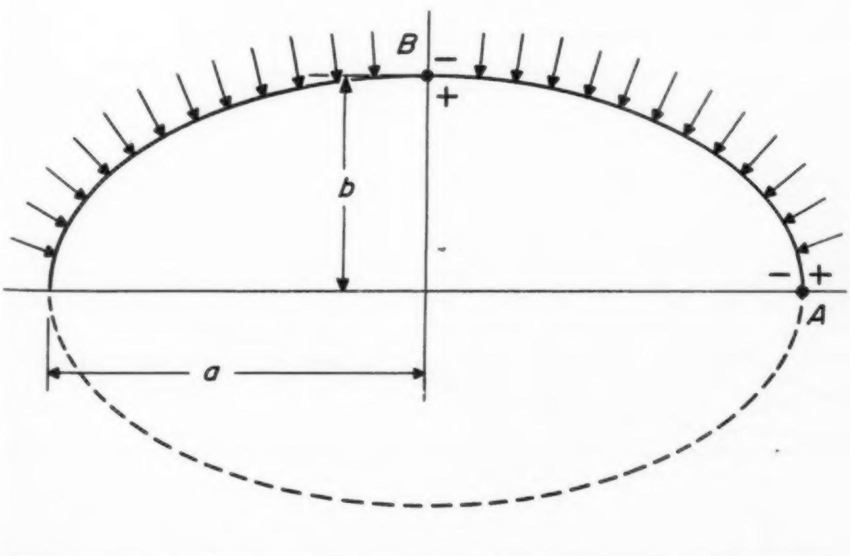


Fig. 1—Thin-wall elliptical tube under external pressure conditions. Maximum and minimum bending stresses occur at the end of the semiaxes, with algebraic signs as shown. Bending stress is tensile on outside fiber at *A* and compressive on outside fiber at *B*

$\sigma_{hA} = pa/t$ and at B is $\sigma_{hB} = pb/t$. Symbols are defined in the accompanying nomenclature.

Bending stresses may be evaluated at any section using Mita's method of determining the bending moment from the geometry of the elliptical section in question. Since maximum and minimum bending stresses are of prime importance to the designer, the family of curves given in *Figs*. 2, 3, 4, 5 permit a quick evaluation of these bending stresses at the ends of the semiaxes of the elliptical section. The bending stress at A in *Fig*. 1 can be readily determined by using the a/b ratio and the corresponding a curve in the chart in *Fig*. 2 to find the value of $\sigma_{bA}\ t^2/3p$. Bending stresses at B in *Fig*. 1 can be found in exactly the same manner by using the chart shown in *Fig*. 3. The algebraic sign of the bending stresses can be established through the use of the following rule: "If the pressure is applied externally to the elliptical tube as shown in *Fig*. 1, the bending stress on the outside fiber at A is tensile and at B it is compressive." The total stresses at A and B, respectively, are $\sigma_{tA} = \sigma_{bA} + \sigma_{hA}$ and $\sigma_{tB} = \sigma_{bB} + \sigma_{hB}$.

The charts in *Figs*. 4 and 5 are to be used particularly for out-of-round tubing or cylinders whose ratio of maximum to minimum diameters is close to 1.

This stress solution method is applicable for both internal and external fluid pressure conditions. For external pressure, the algebraic signs of the stresses are as shown in *Fig*. 1. For internal pressure, the signs are simply reversed. The foregoing relationships are essentially valid until the tube buckles under external pressure or until the elliptic-

Fig. 2—Curves to determine bending stress, σ_{bA}, at end of major axis of thin elliptical tube under fluid pressure

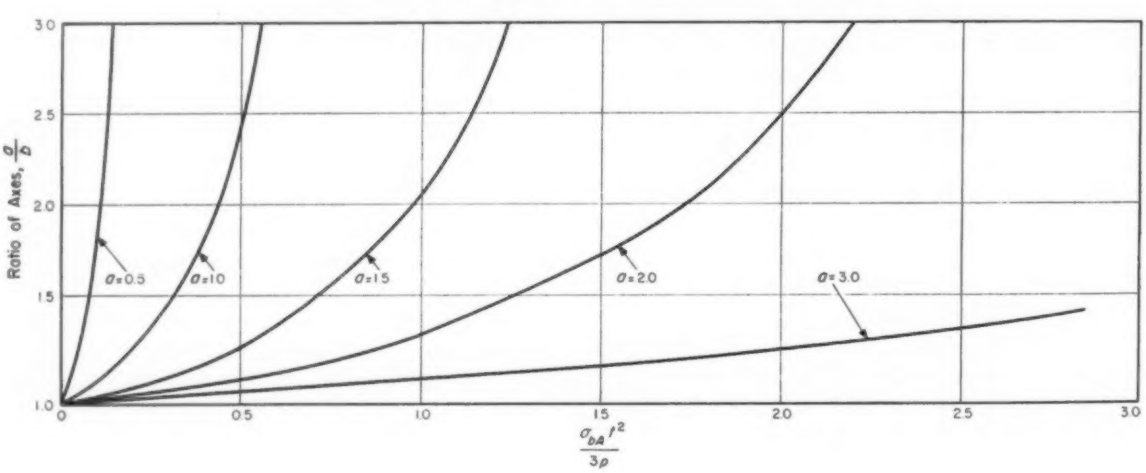
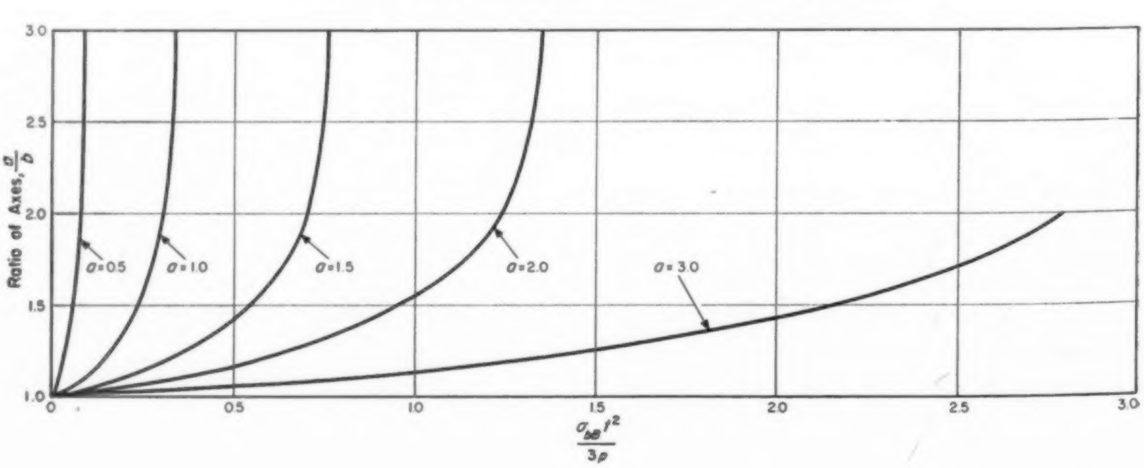


Fig. 3—Curves to determine bending stress, σ_{bB}, at end of minor axis of thin elliptical tube under fluid pressure



al tube deforms into a circular tube under internal pressure.

EXAMPLE: Consider the case of a 3-inch diameter tube, designed to carry gases at 400 psi, whose wall thickness is 0.0800-inch. If the tube is assumed to be a perfect circular cylinder, the bending stresses are equal to zero and the hoop stresses are equal to 7,500 psi, which is satisfactory for most engineering materials. However, if the tube is only 3 per cent out of round, which is equivalent to a difference of 0.090-inch between maximum and minimum diameters, appreciable bending stresses will be introduced. Thus, if the maximum diameter of the out-of-round tube is 3.000 inches and the minimum diameter is 2.910 inches, then $a = 1.500$ inches, $b = 1.455$ inches and $a/b = 1.0309$. From *Fig.* 4, $\sigma_{bA}\ t^2/3p = 0.061$ and from *Fig.* 5, $\sigma_{bB}\ t^2/3p = 0.074$. Solution of these relations gives a compression stress value on the outside fiber $\sigma_{bA} = 11{,}400$ psi and a tension stress value on the outside fiber $\sigma_{bB} = 13{,}900$ psi.

The hoop stresses in the out-of-round tube will be approximately the same as those in the perfect circular tube. Therefore, the total maximum stresses are $\sigma_{tA} = 11{,}400 + 7{,}500 = 18{,}900$ psi tension on the inside fiber and $\sigma_{tB} = 13{,}900 + 7{,}500 = 21{,}400$ psi tension on the outside fiber.

The effect of the eccentricity is clearly shown in this example. The effect of a 3 per cent out of roundness of the tube increased stress 152 per cent at *A* and 185 per cent at *B*. Of course, as the internal pressure is increased, the eccentricity of the cylinder will decrease somewhat, thus reducing the stress values. If the pressure is applied externally, the eccentricity of the cylinder will increase and its effect on the stresses will be greater.

Nomenclature

a = Length of semimajor axis of ellipse, in.
b = Length of semiminor axis of ellipse, in.
p = Internal or external fluid pressure, psi
t = Wall thickness of tube, in.
σ_b = Bending stress in tube, psi
σ_h = Hoop stress in tube, psi
σ_t = Total stress in tube, psi

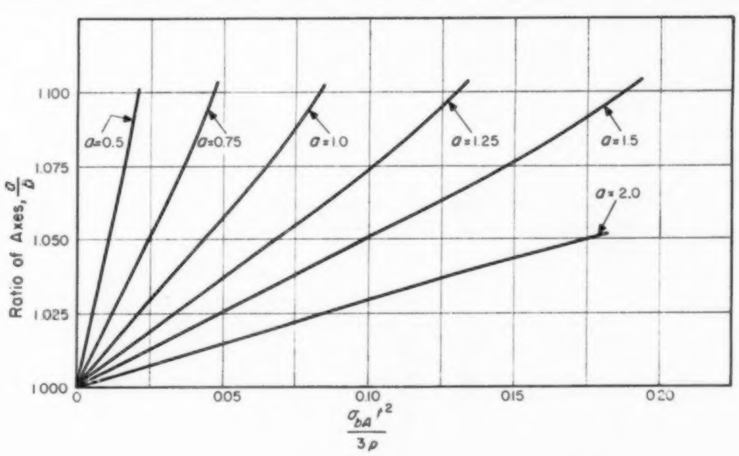


Fig. 4—Curves to determine bending stress, σ_{bA}, produced by fluid pressure at end of major diameter in circular tube slightly out of round

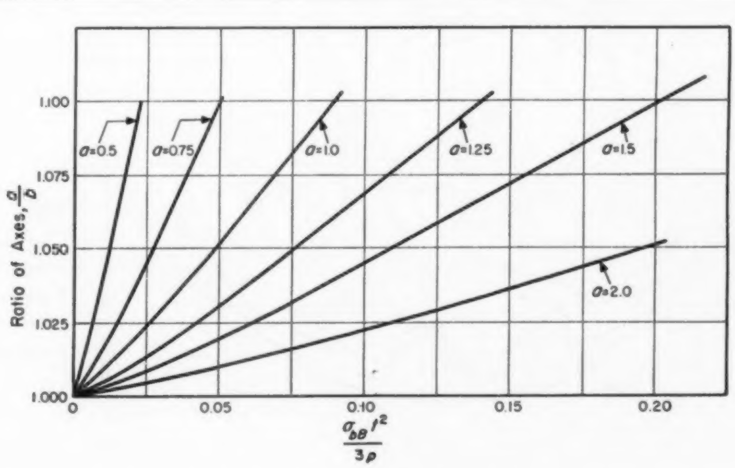
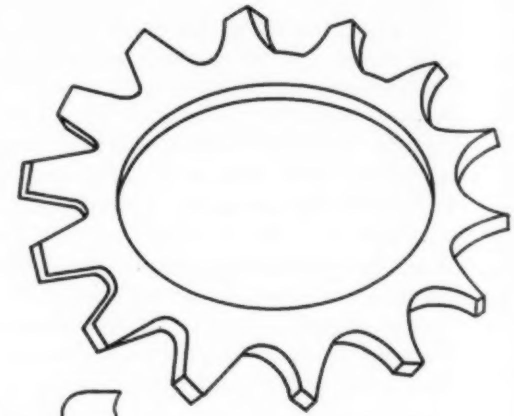
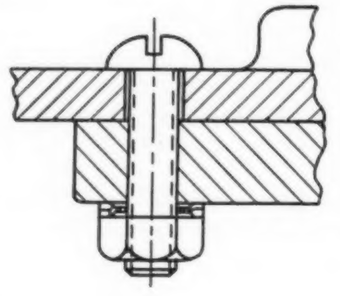


Fig. 5—Curves to determine bending stress, σ_{bB}, produced by fluid pressure at end of minor diameter in circular tube slightly out of round

Lockwashers

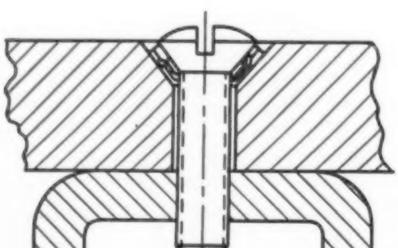
Simple and efficient, lockwashers have become well established as convenient and low-cost locking devices for fastener assemblies. Available types include a wide variety of shapes and sizes to meet different application requirements. Standard products of Shakeproof Inc. are illustrated in the accompanying views of typical lockwasher types and applications. Designed primarily to provide protection against the loosening action of vibration, these lockwashers are also suitable where electrical connection is necessary. Tapered-twisted teeth, which provide locking action, bite into the wire or bonding braid and the nut, screw head or plate, thus providing secure electrical contact.

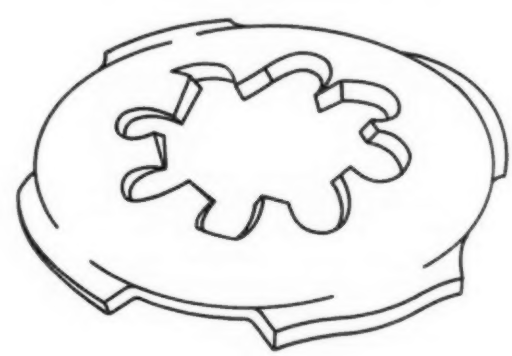


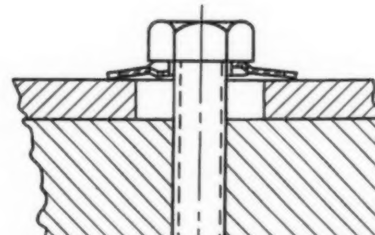


External type has teeth on large radius, thus providing high torsional resistance. These lockwashers should be used with fasteners having heads large enough to engage the lockwasher teeth. Pan or binding heads, for example, are suitable.

Countersunk type has conical shape for assembly with flat or oval head screws.

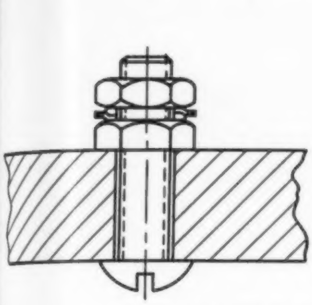


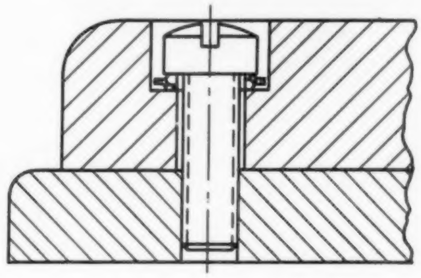


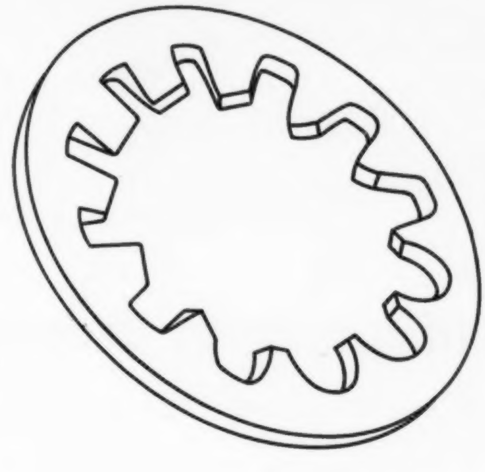


Dished type is suitable for same applications as dome type but should be used where resilience, rather than rigidity, is of primary importance. This type is also available with a plain or toothed periphery. Both dome and dished lockwasher types are crowned or arched so that a "biting" engagement is made with the bolt head or nut.

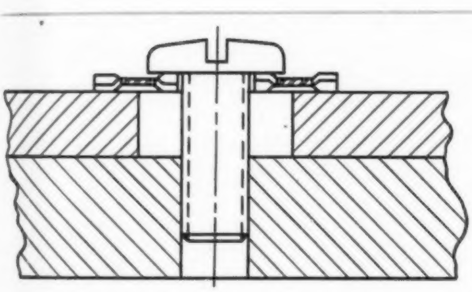
Practical solutions for design problems with standard components

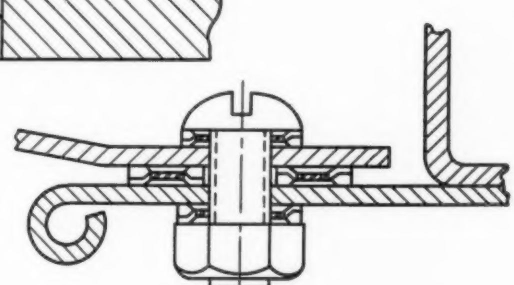






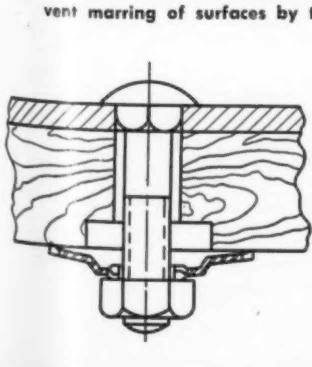
Internal type is recommended for use with fillister head, or other similar small-head screws and SAE nuts. This type is also useful for applications where it is desirable to conceal the teeth, either for appearance or to prevent snagging. A modification of this type with increased thickness is also available for heavy-duty service in motor blocks and heavy machinery or equipment.

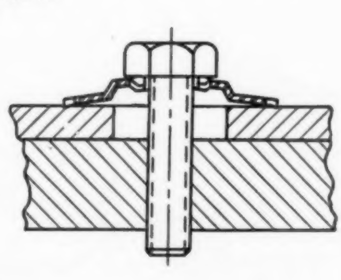


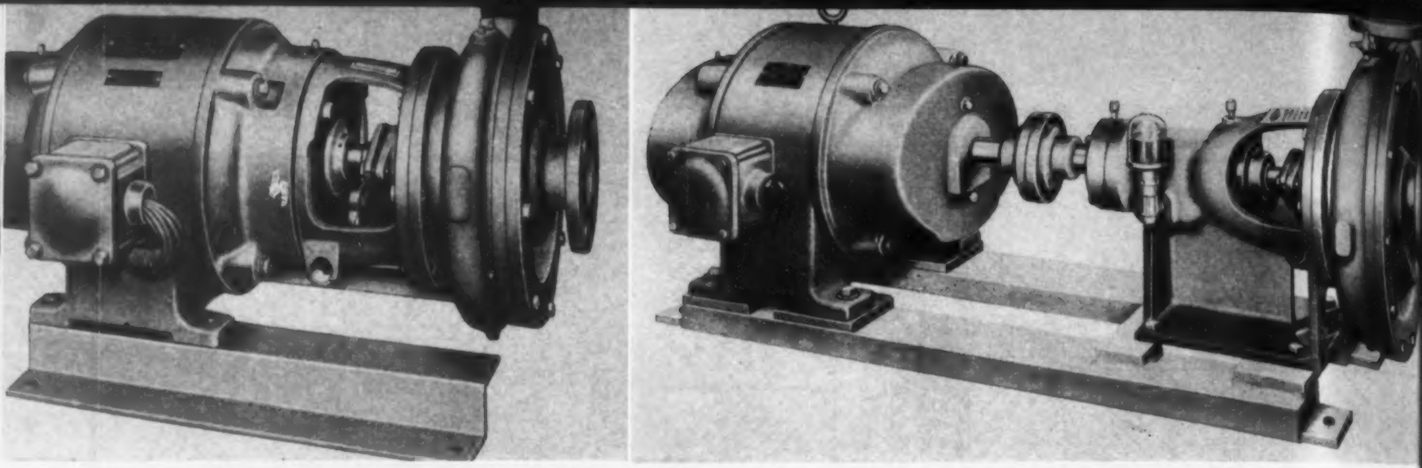


External-internal type is designed for use (1) where a larger bearing surface is desired, (2) where screw holes are elongated or oversize and (3) as an insert between two adjustable members where rotational or longitudinal position adjustments must be maintained at original setting. In addition, because of the extra set of locking teeth, these washers are particularly suited for electrical connections.

Dome type acts to distribute the applied load and is recommended for use with soft or thin materials where considerable force is needed for locking. Because of their shape, these types are also useful with oversize or elongated screw holes. Washers are available with a toothed periphery, as shown, to increase resistance to shifting or with a plain periphery to prevent marring of surfaces by the biting teeth.

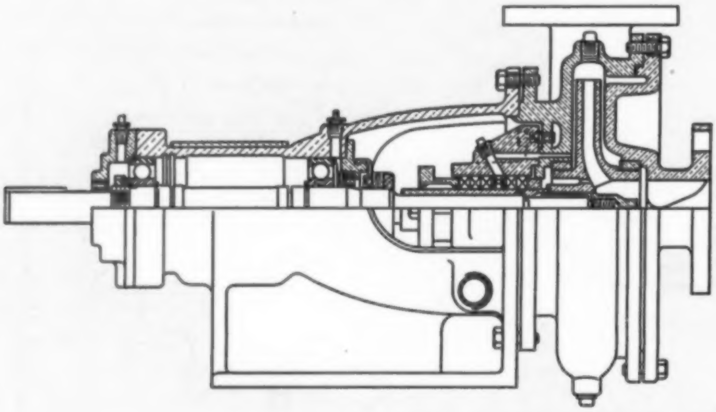


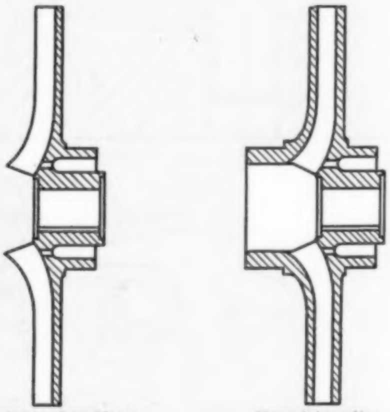




Centrifugal Pumps Designed for Parts Interchangeability

EASE and rapidity with which various components of a new series of centrifugal pumps may be interchanged results in what might be described as custom-built, off-the-shelf pumps. Built by Ampco Metal Inc., the 1750-rpm, single-section units are available in sizes ranging from fractional flow to 600 gpm. Basic pump units may be constructed of Ampco or nickel-chrome alloys to provide the required degree of corrosion and erosion resistance for pumping an extremely wide variety of liquids. Two basic styles are for flange or foot mounting. Two pedestals provide a choice of center line heights to accommodate various motors. Semiopen and closed impellers are used.

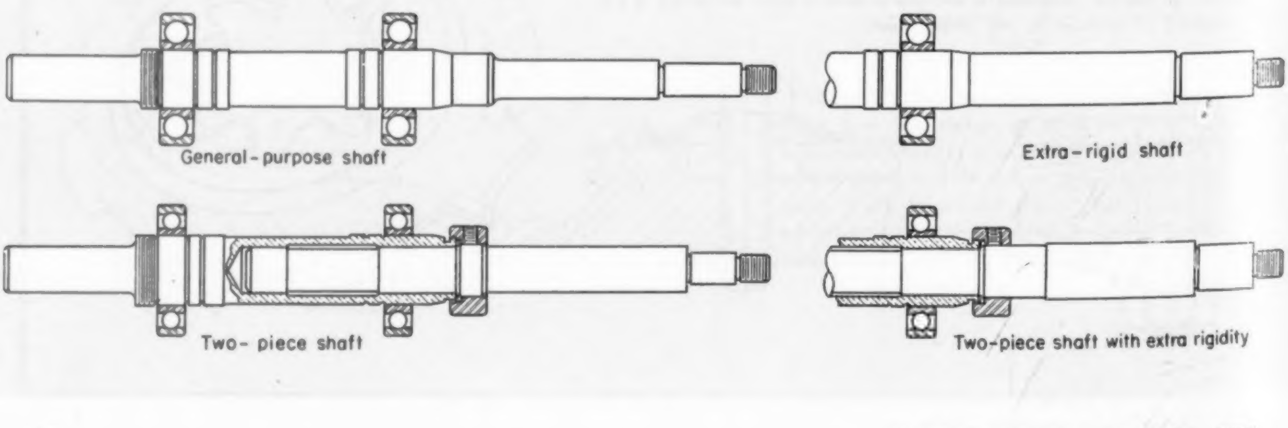




Semiopen impeller

Closed impeller

Four shaft variations are available. The basic or general-purpose shaft is of sufficient strength and rigidity so that deformation is restricted to less than the running clearance. An extrarigid shaft may be used in severe applications or with seals requiring practically no shaft deformation. Two-piece shafts in general purpose and extrarigid weights allow removal and replacement of major rotating pump parts without disturbing bearings, coupling, drive or alignment. All four shafts are interchangeable in a housing, and each may be used with different types of bearings and seals.

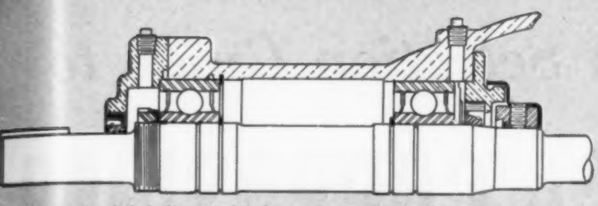


General-purpose shaft

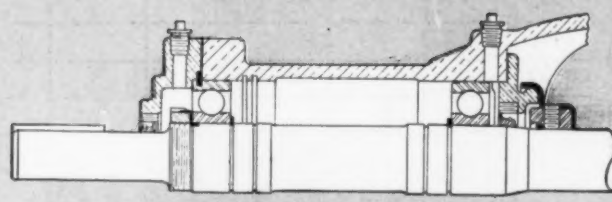
Extra-rigid shaft

Two-piece shaft

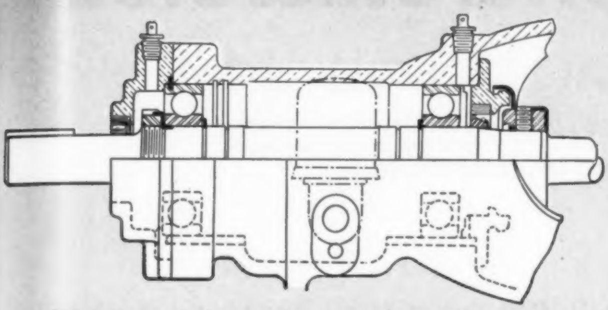
Two-piece shaft with extra rigidity



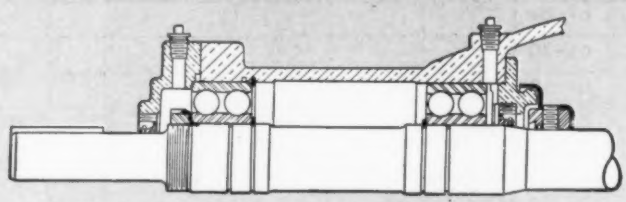
Prepacked lubricant single-row double-width bearings



Replenishable grease lubricated

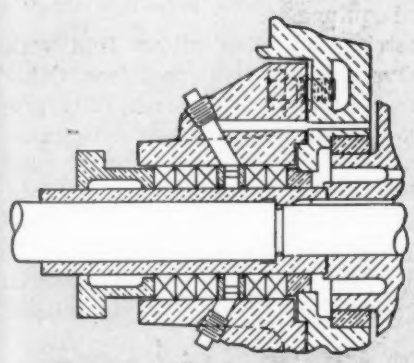


Oil-lubricated, constant-level, single-row bearings

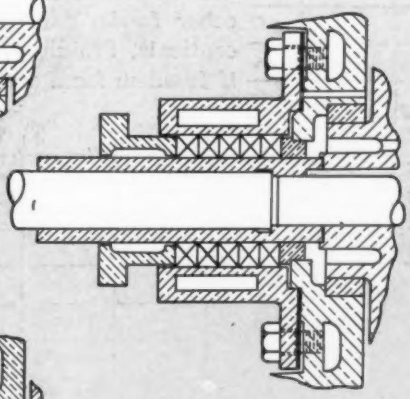


Double-row bearings for oil or grease lubrication

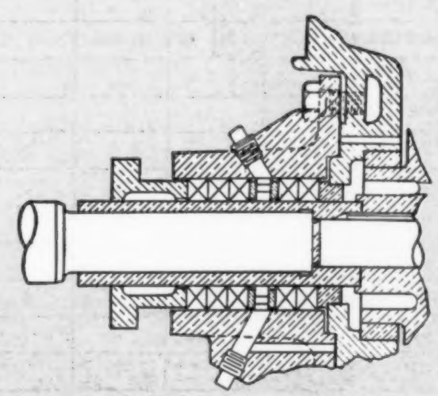
Four different bearing and lubrication options are shown here using the same shaft. Bearings may be single-row, single-row double-width, or double row. Lubrication may be permanent, or replenishable greasing or oiling systems can be used. Medium or light-duty bearings are used depending upon the shaft selected.



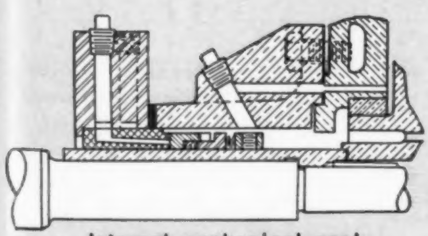
Packed stuffing box with internal liquid seal



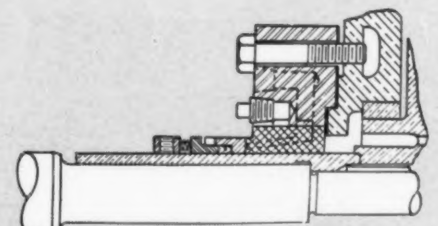
Jacketed stuffing box-temperature control



Packed stuffing box orientated to block internal seal for external lubricating sealing or flushing

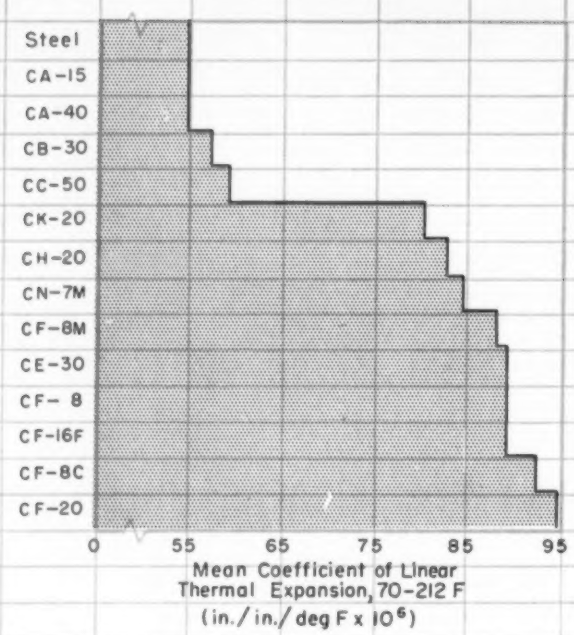


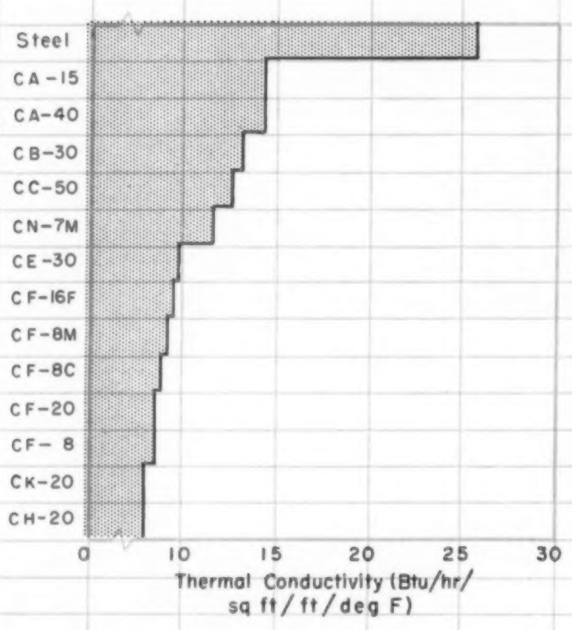
Internal mechanical seal-lubricated and cooled

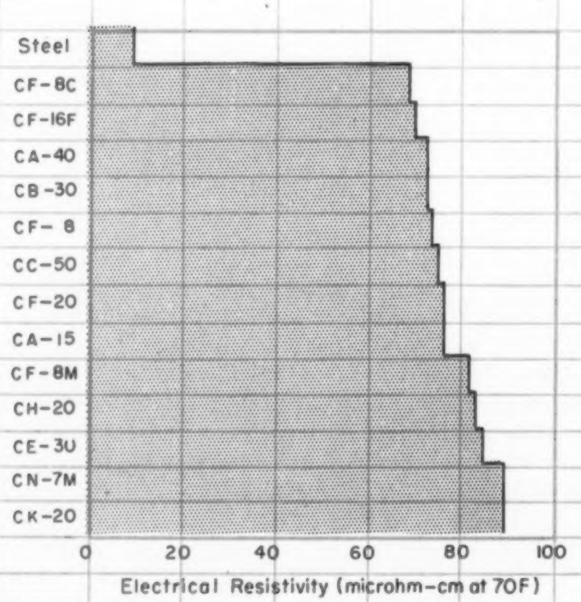


External mechanical seal-lubricated and cooled

Shaft seals may be packed stuffing box or mechanical type. Packed stuffing-boxes have either internal, external or flushing seals and may be changed from one to the other by rotating a single part. Stuffing-box arrangement can be changed without changing parts or dismantling. Water-cooled boxes are also available. Both inside and outside mechanical seals are applied interchangeably to these pumps. Space is provided for seals to be lubricated and/or cooled.







A Selection Guide to

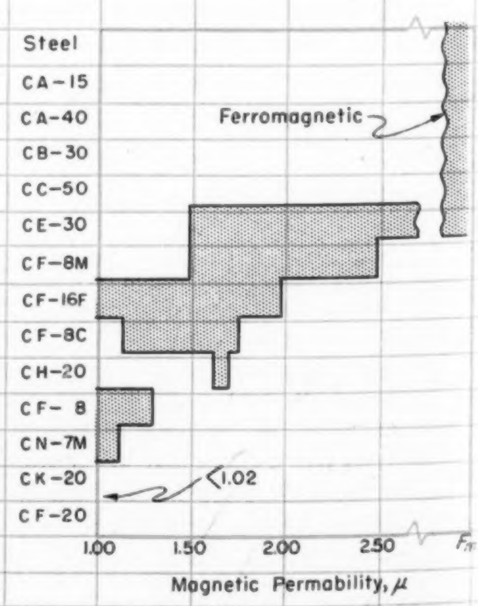
CORROSION-

By E. A. Schoefer
Executive Vice President
Alloy Casting Institute
Mineola, N. Y.

DURING the past few decades the handling and processing of corrosive substances has been revolutionized by the iron-chromium and iron-chromium-nickel alloys familiarly known as stainless steels. These alloys combine resistance to many corrodents with mechanical and fabricating characteristics comparable to ordinary steel—all at a cost which permits their use in large quantities in industrial equipment.

In some industries, stainless alloys find wide application for severely corrosive conditions. Other industries, whose products must be carefully protected against contamination, also use substantial amounts of stainless alloys to ensure product quality. Many relatively mild corrosives, for instance, are handled in the processing of dairy products and other foods, and in the manufacture of pharmaceuticals. Stainless alloys frequently are essential if freedom from contamination is to be maintained.

Fig. 1—Physical properties of corrosion-resistant high-alloy castings



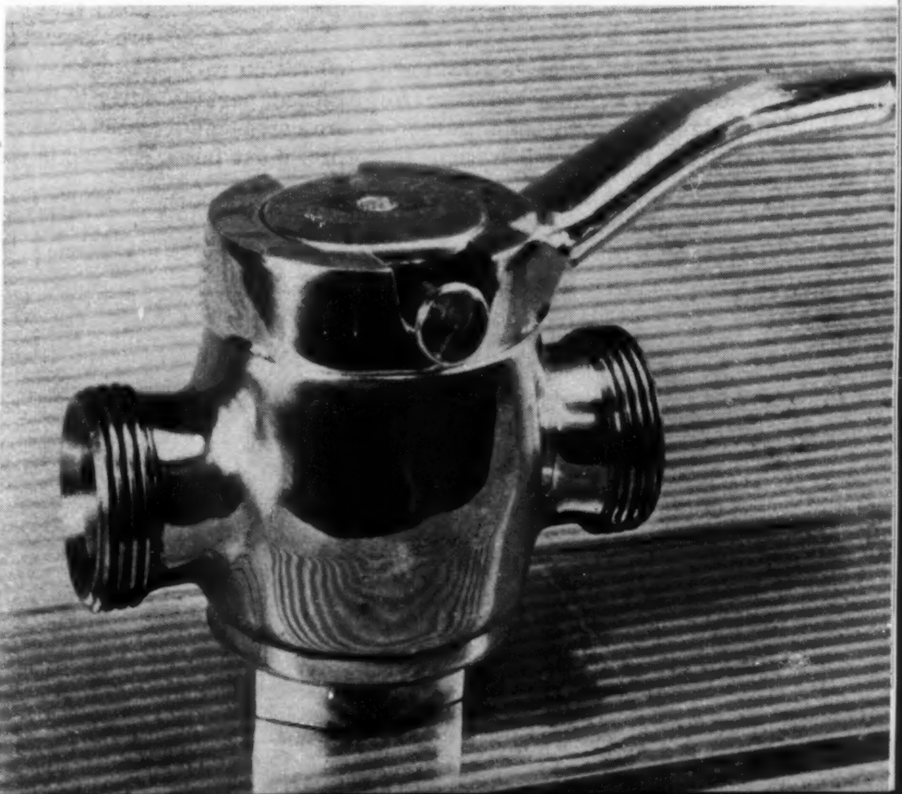
RESISTANT CAST ALLOYS

How to pick the right cast stainless alloy for corrosion resistance, fabricating characteristics, mechanical properties, and cost

This article will not attempt an exhaustive discussion of which alloy among the various commercial types can be used for a specific corrosive. Under certain relatively mild conditions any of the standard grades will serve, but when conditions are critical the metallurgist and the corrosion specialist must be consulted. Rather, an attempt will be made to provide guidance in selecting the most suitable cast alloy from the standpoints of physical properties and economy of fabrication. As far as possible, this guidance will be based on typical properties to be expected from commercially obtainable materials and on the experience of the high-alloy foundry industry in the production and further fabrication of corrosion-resistant castings.

Castings are made of the corrosion-resistant alloys for the same reasons that other metals are used in the cast form: (1) relative ease and economy of obtaining integral components of complex shape by casting, and (2) efficient distribution of metal for optimum strength-weight ratio, rigidity, and uniformity of properties in all directions. In addition, it is frequently easier to obtain castings of a specific alloy composition than similar rolled or forged products, particularly if the quantity required is small. Certain desirable compositions, in fact, cannot be rolled or forged successfully.

There are corresponding grades of cast and wrought corrosion-resistant (stainless) alloys, but chemical compositions are not identical. Although superficially minor, differences in chemistry are metallurgically important in proper balancing of the compositions to provide workability on the one hand and castability on the other. In general, corrosion resistance of corresponding cast and wrought alloys is equivalent. Designations for the cast corrosion-resistant alloys are shown in *Table* 1 to-



Sanitary valve for use in Terramycin production. Made by Tri-Clover Machine Co. of CF-8 corrosion-resistant cast alloy, the fitting is used by Charles Pfizer and Co. because of ease of cleaning and ability to withstand temperature cycling in sterilization.

Table 1—Standard ACI Corrosion-Resistant Cast Alloys

Designation (Alloy Casting Institute)*	Corresponding Wrought Alloy Type†	Composition (%, bal Fe) C	Mn (max)	Si (max)	P (max)	S (max)	Cr	Ni	Other
CA-15	410	0.15 max	1.00	1.50	0.04	0.04	11.5-14	1 max	0.5 max Mo§
CA-40	420	0.20-0.40	1.00	1.50	0.04	0.04	11.5-14	1 max	0.5 max Mo§
CB-30	431	0.30 max	1.00	1.00	0.04	0.04	18-22	2 max	....
CC-50	446	0.50 max	1.00	1.00	0.04	0.04	26-30	4 max	....
CE-30	...	0.30 max	1.50	2.00	0.04	0.04	26-30	8-11	....
CF-8	304	0.08 max	1.50	2.00	0.04	0.04	18-21	8-11	....
CF-20	302	0.20 max	1.50	2.00	0.04	0.04	18-21	8-11	....
CF-8M	316	0.08 max	1.50	1.50	0.04	0.04	18-21	9-12	2.0-3.0 Mo
CF-12M	316	0.12 max	1.50	1.50	0.04	0.04	18-21	9-12	2.0-3.0 Mo
CF-8C	347	0.08 max	1.50	2.00	0.04	0.04	18-21	9-12	Cb or Cb-Ta‡
CF-16F	303	0.16 max	1.50	2.00	0.17	0.04	18-21	9-12	1.5 max Mo, 0.20-0.35 Se
CH-20	309	0.20 max	1.50	2.00	0.04	0.04	22-26	12-15	....
CK-20	310	0.20 max	1.50	2.00	0.04	0.04	23-27	19-22	....
CN-7M	...	0.07 max	1.50	**	0.04	0.04	18-22	21-31	Mo-Cu**

*Most standard grades listed are covered for general application by ASTM specification A296-49T. ASTM specifications A217-49T, A351-52T, and A362-52T also apply to some grades.

†Listed only for convenience in determining corresponding wrought and cast grades. Because cast alloy chemical composition ranges are *not the same* as wrought composition ranges, cast alloy designations should be used for proper identification.

§Molybdenum not intentionally added.

‡Cb—8×C min, 1.0 max; or Cb-Ta—10×C min, 1.35 max.

**Several proprietary alloy compositions fall within the stated chromium and nickel ranges, and contain varying amounts of silicon, molybdenum and copper. These are available from licensed producers only.

gether wth the related wrought type numbers and the ranges of alloy contents. These designations—not those for wrought forms—should be used for specifying castings.

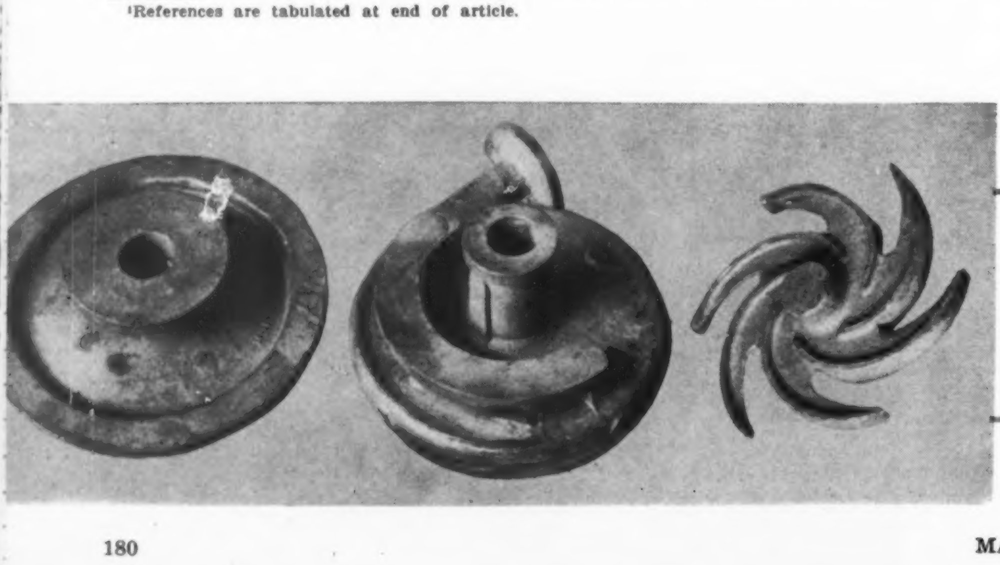
General characteristics of the cast high alloys were described in a previous issue of MACHINE DESIGN,[1] and reference to that article should be made for such information. An arbitrary distinction, based on operating temperature, is made between the heat-resistant and corrosion-resistant grades, but the latter as a group are normally characterized by lower nickel, chromium and carbon contents. The following discussion will be devoted to corrosion-resistant types only.

Selection for Corrosive: Ordinarily, corrosion resistance is the prime requisite for exposed parts where danger of contamination or severe corrosion is involved. First consideration, therefore, must be given to the class of alloys suitable for the contemplated service conditions. The corrosion-resistant cast alloys are usually classified as:

1. Straight chromium, hardenable (type CA)
2. Straight chromium, nonhardenable (types CB and CC)
3. Iron-chromium-nickel (types CE, CF, CH and CK)
4. Iron-nickel-chromium (type CN)

Stainless steels are corrosion resistant because of the phenomenon of passivation, which results in very low rates of corrosion attack in many solutions that rapidly corrode ordinary steels. Chromium imparts passivity to ferrous alloys when it is present in excess of about 11 per cent, particularly if conditions are strongly oxidizing. Corrosion resistance is improved as chromium content is increased beyond the minimum required for passivity.

[1]References are tabulated at end of article.



Parts for centrifugal mine pumps cast of type CC-50 alloy. Each casting weighs about 15 pounds.

Addition of nickel to iron-chromium alloys tends to improve ductility and impact strength. Resistance to corrosion by neutral chloride solutions and weakly oxidizing acids increases in proportion to nickel content. Molybdenum additions increase resistance to pitting attack in chloride solutions, and extend the range of passivity in solutions of low oxidizing capacity. In all stainless alloy types, the lower the carbon content, the more corrosion resistance is enhanced.

General areas of corrosive conditions resisted satisfactorily by a given alloy or group of alloys cannot be outlined simply. Numerous factors in industrial processes influence the maintenance of a passive surface film. Chief among these are the concentration, temperature, aeration, velocity and contamination of the corrosive. In general, corrosive attack tends to increase: (1) with increased concentration; (2) with increased temperature (a rough rule is that corrosion rate doubles with each 10C increase in temperature); and (3) with increased velocity. Because corrosion-resistant alloys are frequently used to handle flowing corrosives, it is important not to overlook the erosive effect of high velocity. Contamination of solutions by free halogen ions can be very destructive to stainless alloys by causing local breakdown of passivity, resulting in pitting. Normally, the more aeration the better, since the oxidizing capacity of the solution is increased. But where design of a part contributes to differential aeration the surface exposed to the low-oxygen-content solution may suffer accelerated attack. Use of cast structures often permits the designer to eliminate cracks and crevices that might cause differential aeration or concentration of the solution.

Air atmospheres, food products, oxidizing salts and acids, and ordinary water are examples of mild corrosives which can be handled satisfactorily at room temperature by all the corrosion-resistant cast alloy types previously listed. As temperatures and concentrations of corrodents are increased under strongly oxidizing conditions, the choice is narrowed to the ferritic chromium alloys (class 2) and, except for the CF-8M grade, to the austenitic chromium-nickel alloys (class 3). Strong, hot, weakly oxidizing solutions such as sulfurous, sulfuric, acetic and phosphoric acids, normally limit the selection to the high-chromium CH-20 and CK-20 grades or to the molybdenum-containing types CF-8M and CN-7M. The latter two alloys are the only standard grades suitable for handling hot chlorides, hydrochloric or hydrofluoric acids, and then only after the most cautious evaluation of service conditions.

Thus, a conflict can arise between the demand for corrosion resistance and the desired mechani-

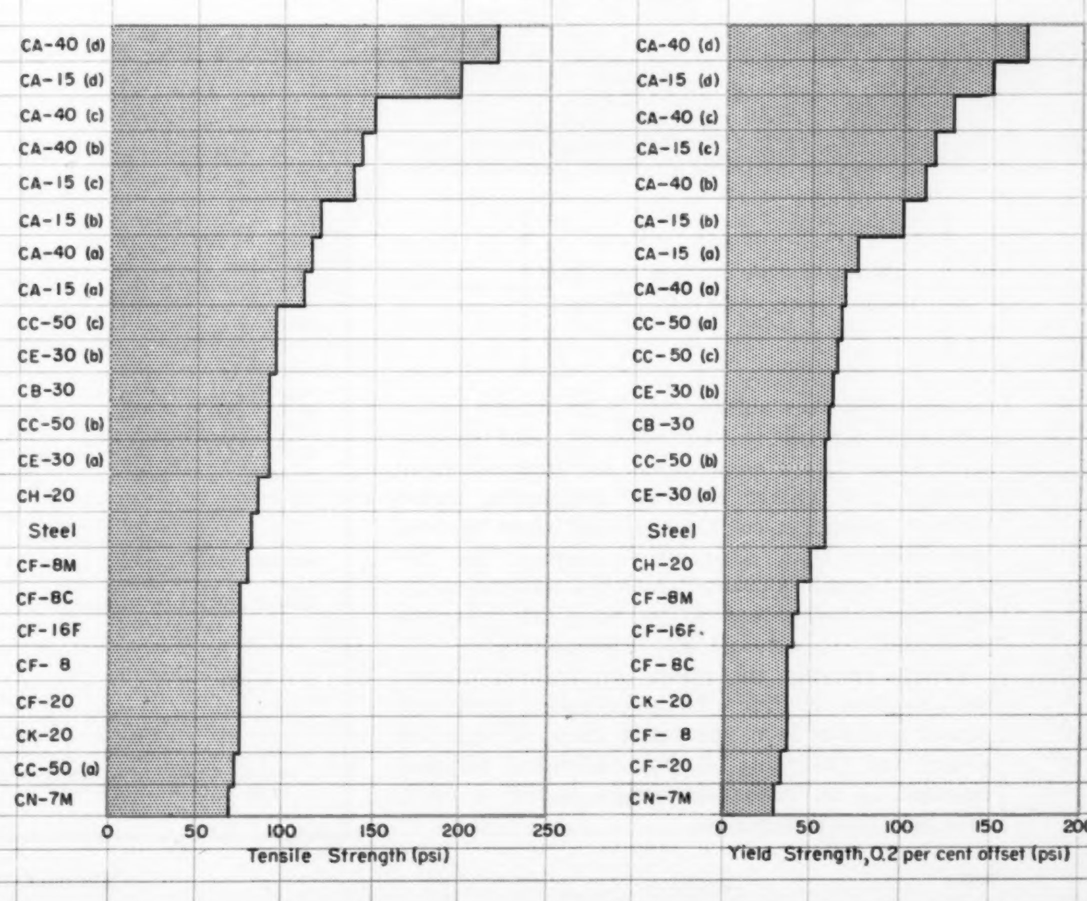
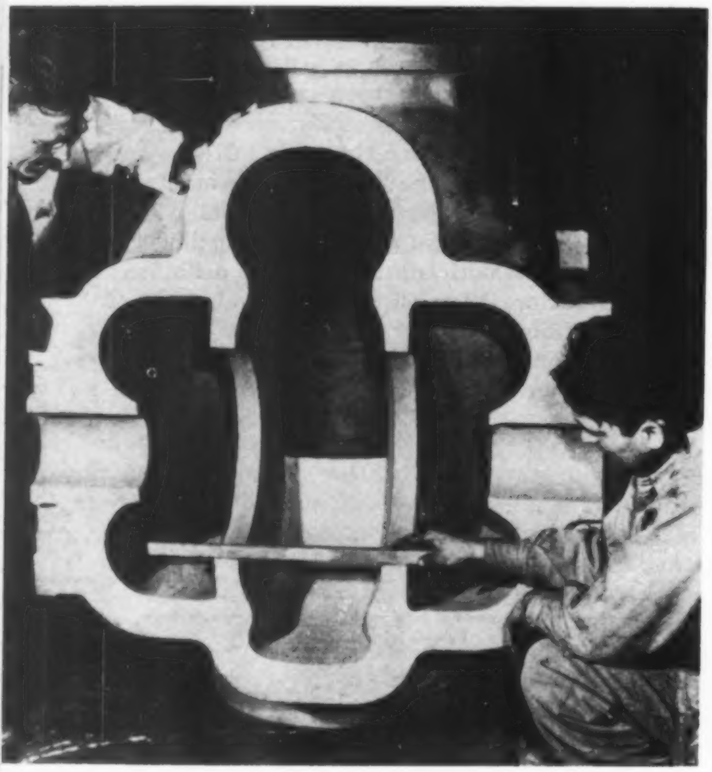


Fig. 2—Strength of cast corrosion-resistant alloys. See *Table* 5 for heat-treatment code. Steel is 0.30 C, WQ from 1650 F, tempered at 1200 F

cal properties. If the corrosion situation is relatively mild, the designer is permitted a wide choice for meeting mechanical requirements. Conversely, he must fit his mechanical design to the properties available in a smaller group of alloys if the corrosive situation is severe. Further consideration of this subject is outside the scope of this article, except to urge that before making his selection the designer seek the advise of a qualified metallurgist or an experienced producer of corrosion-resistant castings.

Selection for Physical Properties: Physical constants for the corrosion-resistant alloys show



Steam-turbine casing cast in ACI type CK-20 alloy.

several important differences from carbon steel. Although density, elastic modulus, and specific heat, *Table* 2, are comparable, the high alloys in general have higher electrical resistance, larger thermal expansion coefficients, and lower thermal conductivity than plain steel. Except for the straight chromium grades which are ferromagnetic, the corrosion-resistant alloys have low magnetic permeability or are virtually nonmagnetic.

Charts ranking the alloys by various properties are given in *Fig.* 1. If the corrosion conditions permit a choice from the entire group of stainless alloys, and the value of some individual physical constant is an important design factor, a fairly wide selection is available.

Selection for Further Fabrication: Corrosion-resistant castings are seldom put into service in the "rough-cast" condition since they are normally components of larger and more complex structures. The designer, therefore, should consider the requirements of further fabrication in connection with the machining and welding characteristics of the alloy he may be planning to use.

MACHINING: Where only a limited amount of machining is involved, comparative machinability of the grades is not an important factor. All the corrosion-resistant cast alloys are machinable if proper techniques are employed. The chromium-nickel grades tend to work-harden rapidly if cutting tools are permitted to rub or scrape the surface. The tool must, therefore, continually enter into the metal. This also holds for the straight chromium alloys even though they work-harden

Table 2—Physical Constants

Type	Density (lb/cu in.)	Tensile Elastic Modulus (million psi)	Specific Heat (Btu/lb/deg F, at 70 F)
CA-15	0.275	29	0.11
CA-40	0.275	29	0.11
CB-30	0.272	29	0.11
CC-50	0.272	29	0.12
CE-30	0.277	25	0.14
CF-8	0.280	28	0.12
CF-20	0.280	28	0.12
CF-8M	0.280	28	0.12
CF-8C	0.280	28	0.12
CF-16F	0.280	28	0.12
CH-20	0.279	28	0.12
CK-20	0.280	29	0.12
CN-7M	0.289	24	0.11
Steel	0.283	30	0.12

Source: *ACI Data Sheets*

Table 3—Machining Speeds and Feeds

Alloy Type	Rough Turning Speed* (sfpm)	Rough Turning Feed (ipr)	Drilling Speed (sfpm)	Tapping Speed (sfpm)
CA-15	40-50	0.010-0.030	35-70	10-25
CA-40	25-35	0.030-0.040	30-60	10-20
CB-30	40-50	0.020-0.030	30-60	10-25
CC-50	40-50	0.025-0.035	40-60	10-25
CE-30	30-40	0.020-0.025	30-60	10-25
CF-8	25-35	0.020-0.025	20-40	10-20
CF-20	25-35	0.020-0.025	20-40	10-20
CF-8C	30-40	0.020-0.025	30-60	10-25
CF-8M	25-35	0.020-0.025	20-50	10-20
CF-12M	25-35	0.020-0.025	20-50	10-20
CF-16F	45-55	0.020-0.025	30-80	15-30
CH-20	25-35	0.020-0.025	20-50	10-20
CK-20	25-35	0.020-0.025	20-40	10-20
CN-7M	45-55	0.020-0.025	30-60	10-25

Drilling Feeds: Drill Diam (in.)	Feed (ipr)
under ⅛	0.001-0.002
⅛ to ¼	0.002-0.004
¼ to ½	0.004-0.007
½ to 1	0.007-0.015
over 1	0.015-0.025

*For high-speed tools; about twice these speeds for carbide tools.
Source: *ACI Data Sheets*

at a much slower rate. On all grades slow feeds, deep cuts and powerful, rigid machines are necessary for best results. Good lubrication and cooling is needed because of low thermal conductivities of the alloys.

If considerable machining of a casting is required, and corrosion conditions are not too severe, the CA-15 grade is often a good choice. For more corrosive service where the CF-20 alloy might normally be selected, the CF-16F type containing 0.20 to 0.35 per cent selenium provides equivalent corrosion resistance, but can be machined at almost twice the speed. Rough turning, drilling and tapping speeds and feeds satisfactory for all the grades are listed in *Table* 3. The values given for turning are for high-speed steel tools. On production work, about double these speeds may be attained through the use of carbide tools.

WELDING: Except in particular cases where cost or convenience of heat treatment is a factor, the designer is not limited in his choice of alloy by considerations of weldability. It is sometimes desirable to join castings with other castings or with wrought material by welding.

Table 4—Welding Procedures for High-Alloy Castings

Cast Alloy Type	Heat Treatment (deg F) Preweld	Postweld*	Electrode Type No.
CA-15	400-600	Cool to 300 min, AC from 1125-1450	410
CA-40	400-600	Cool to 300 min, AC from 1125-1450	420
CB-30	600-800	Cool to 150 max, heat to 1450, AC	431
CC-50	350-400	Heat to 1650 then rapidly air cool	446
CE-30	none	none†	309
CF-8	none	WQ from 1950-2050	308
CF-20	none	WQ from 2000-2100	308
CF-8C	none	none‡	347
CF-8M	none	WQ from 1950-2100	316
CF-12M	none	WQ from 1950-2100	316
CF-16F	none	WQ from 2000-2100	308
CH-20	none	WQ from 2000-2100	309
CK-20	none	WQ from 2000-2150	310
CN-7M	400	Cool very slowly, heat to 2000, WQ	§

*Time at postweld temperature should be sufficiently long to insure uniform heating throughout the areas and sections involved. Quenching of chromium-nickel grades should be drastic enough to insure a rapid rate of cooling from 1600 to 800 F. Air or oil quenching may be adequate with light sections and low-carbon alloys. AC=air cool; WQ=water quench.
†Postweld heat treatment usually is not necessary; however, corrosion resistance and ductility can be improved somewhat by quenching from about 2000 F.
‡Postweld heat treatment (WQ from 1950-2050 F) advisable if stress-corrosion is a factor.
§Rod of composition equivalent to cast alloy is available and should be used.
Source: *ACI Data Sheets*

Table 5—Mechanical Properties of Cast Corrosion-Resistant Alloys*

Alloy Type	Heat Treat Code†	Heat Treatment§	Tensile Strength, (1000 psi)	Yield Strength, 0.2% offset (1000 psi)	Elongation, in 2 in. (per cent)	Brinell Hardness Number	Charpy Impact, keyhole (ft-lb)
CA-15	a	AC from 1800 F, temper at 1450 F	100	75	30	185	35
	b	AC from 1800 F, temper at 1200 F	115	100	22	225	20
	c	AC from 1800 F, temper at 1100 F	135	115	17	260	10
	d	AC from 1800 F, temper at 600 F	200	150	7	390	15
CA-40	a	AC from 1800 F, temper at 1400 F	110	67	18	212	3
	b	AC from 1800 F, temper at 1200 F	140	113	14	267	4
	c	AC from 1800 F, temper at 1100 F	150	125	10	310	2
	d	AC from 1800 F, temper at 600 F	220	165	1	470	1
CB-30		Anneal 1450 F, FC to 1000 F, AC	95	60	15	195	2
CC-50	a	(Under 1% Ni) as cast	70	65	2	212	2‡
	b	(Over 2% Ni, 0.15% N min) as cast	95	60	15	193	45‡
	c	(Over 2% Ni, 0.15% N min) AC from 1900 F	97	65	18	210	..
CE-30	a	As cast	95	60	15	170	..
	b	WQ from 1950-2050 F	97	63	18	170	..
CF-8		WQ from 1950-2050 F	77	37	55	140	75
CF-20		WQ from above 2000 F	77	36	50	163	60
CF-8M, CF-12M		WQ from 1950-2100 F	80	42	50	156-170	70
CF-8C		WQ from 1950-2050 F	77	38	39	149	30
CF-16F		WQ from above 2000 F	77	40	52	150	75
CH-20		WQ from above 2000 F	88	50	38	190	30
CK-20		WQ from above 2100 F	76	38	37	144	50‡
CN-7M		WQ from above 1950-2050 F	69	31	48	130	70

*Representative room-temperature properties; not specification values. †For *Figs.* 2 and 3. §AC—air cool; FC—furnace cool; WQ—water quench. ‡Izod V-notch.
Source: *ACI Data Sheets*

Centrifugally cast rings for jet-engine applications. Alloys used are CA-15, CF-20 and CF-8C.

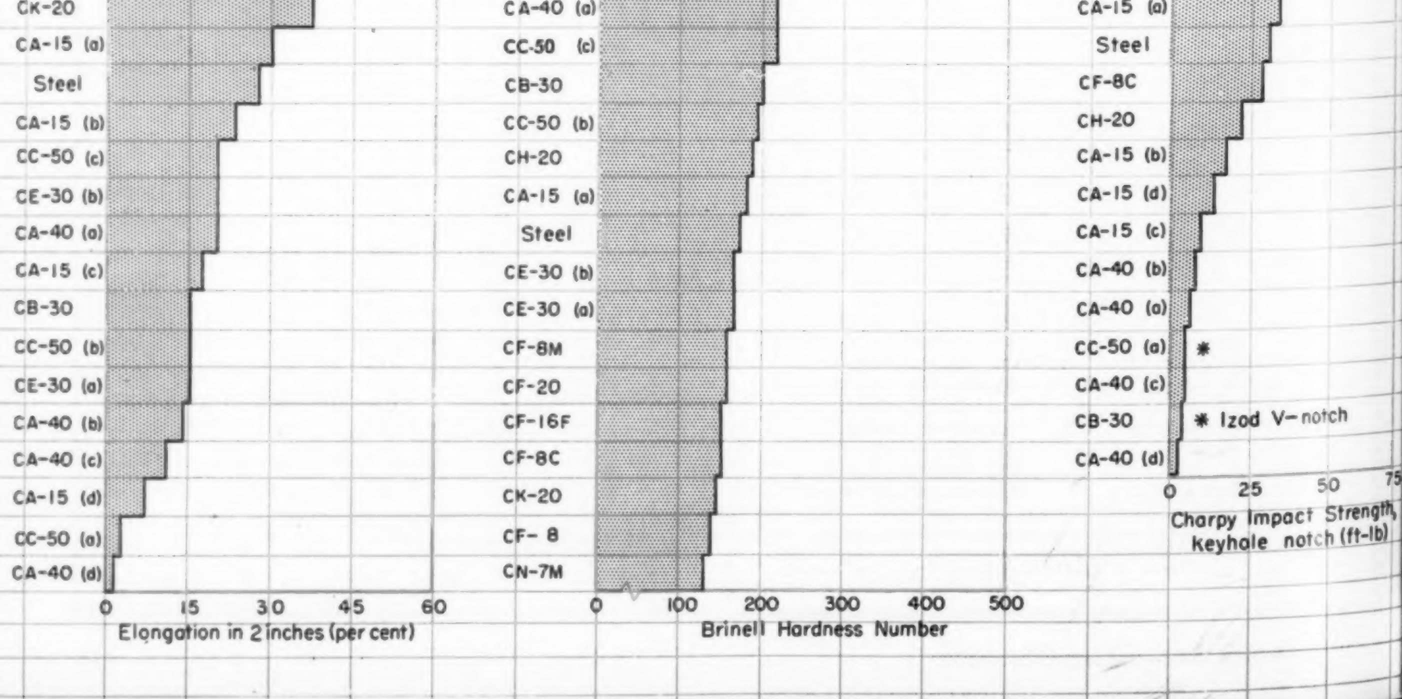
As a class, the straight chromium alloys are less readily welded than the chromium-nickel grades because the castings usually must be heated prior to welding. All of the corrosion-resistant cast alloys can be welded satisfactorily, however, by observing proper precautions.

After welding, most of the grades require heat treatment either to restore mechanical properties or corrosion resistance. Recommended preweld and postweld heat treatments and electrodes are listed in *Table* 4.

When circumstances prevent postweld heat treatment of castings, such as frequently occurs in field welding or where the welded structure is too big to be heated economically, the designer may select the high-chromium grade CE-30, the columbium-stabilized CF-8C type, or one of the special extra-low-carbon varieties becoming available. Light sections of partially ferritic CF-8 and CF-8M types that air cool rapidly can often be welded without subsequent heat treatment and still provide satisfactory corrosion resistance; but for slow-cooling, heavy sections the CF-8C alloy is the preferred choice.

Mechanical Properties: Tensile strengths from 55,000 to 220,000 psi, and hardness from 130 to

Fig. 3—Elongation, hardness and impact strength. See *Table* 5 for heat-treatment code. Steel is 0.30 C, WQ from 1650 F and tempered at 1200 F, except on impact tests where tempered at 1275 F



470 brinell, are available among the cast stainless alloys. Similar wide ranges exist in yield strengths, elongation and impact values. A graphic comparison of the different alloy types is presented in *Figs.* 2 and 3 for values in *Table* 5.

Grades CA-15 and CA-40 are martensitic and are hardenable by heat treatment. Several values are given for each of these alloys on the charts. When fully hardened, the alloys have their best corrosion resistance. The ferritic straight chromium alloys CB-30 and CC-50 are normally supplied in the annealed condition.

Heat treatment of the austenitic grades has only a minor effect on their mechanical properties, because they undergo no change in phase. They must, however, be properly heat treated to ensure complete solution of carbides and thus provide maximum corrosion resistance. Precipitation of chromium carbides during welding causes loss of corrosion resistance in the weld zone, and for this reason postweld heat treatment is required. Columbium carbides instead of chromium carbides are formed in the CF-8C type, and the high chromium content of type CE-30 permits formation of some chromium carbide without deleterious effect. Hence, these grades need not be treated after welding, but castings are usually solution heat treated before delivery.

Foundry Characteristics: Section thicknesses from 3/16-inch up can be cast satisfactorily in all grades. Somewhat lighter sections are occasionally possible depending on casting design, pattern equipment, and chemical composition. Castability is enhanced by high silicon and carbon contents so that unwarranted restrictions should not be placed on these elements. By specifying, for example, a low silicon limit such as is normal for wrought materials, the designer places an unnecessary burden on the foundryman.

Greater difficulty with thin sections is encountered in the straight chromium alloys than in the chromium-nickel types. Thus, unless the hardenability of the CA type or the physical properties such as expansion coefficient or heat conductivity of the CB and CC types are important requirements, consideration should be given to other grades when designs are complex. Even with alloys whose good castability permits designs involving intricate shapes, drastic changes in section should be avoided and uniform thickness should be maintained as far as possible. Finish allowance of ⅛-inch or more should be provided on surfaces to be machined, and this should be considered when sec-

Distintegrator for baby food and other types of food processing. Cast stainless alloy parts in the Rietz Mfg. Co. unit are indicated.

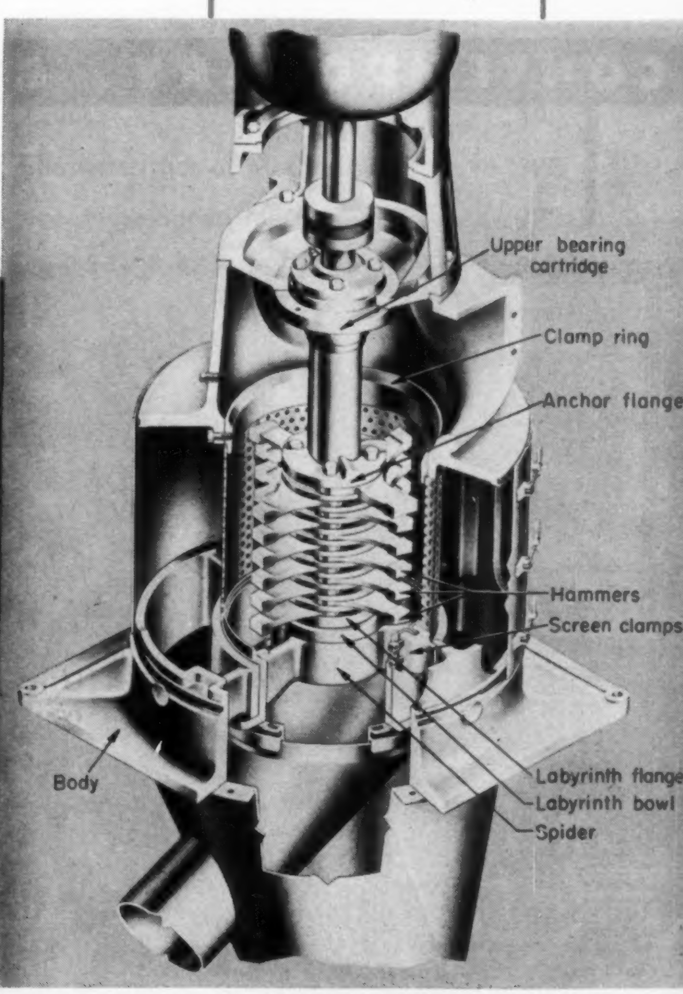
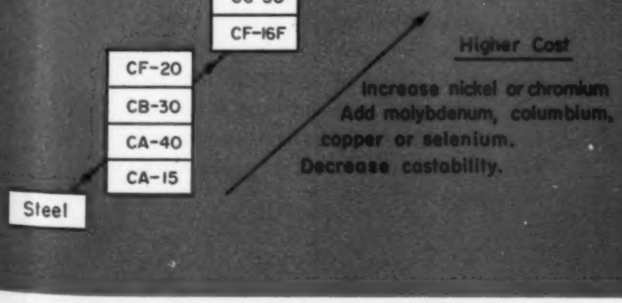


Fig. 4 — Approximate relative cost of various alloys. For a particular casting, costs may differ from indicated relationships



tion thicknesses are planned.

Dimensional tolerances for rough castings are influenced by the quality of pattern equipment provided. In general, over-all dimensions and locations of cored holes can be held to 1/16-inch per foot in sand castings.

Pattern Equipment: As a general rule, best results are obtained when patterns are made or procured by the foundry that will produce the casting. Consultation between the designer and the foundryman during the early stages of design will help avoid later changes required for the producer's foundry practice.

Requirements for gates and risers vary considerably among cast iron, steel and high alloys. Also, solidification contractions of these metals are different. Patterns originally made for castings of one metal, therefore, are usually unsatisfactory for castings of another metal—particularly if dimensional accuracy is desired. Furthermore, a pattern acceptable to one foundry may be wholly unacceptable for producing the same casting design in another shop using a different molding method.

Final Alloy Selection: Previous experience data can be of great assistance in determining the type of alloy to use for a given application. It is to the designer's advantage to obtain as much information as possible at the outset of the problem. If an alloy fails in service for which it should be satisfactory, one may suspect that actual conditions are different from those intended or stated. For example, corrosion products formed at some other part of the system may contaminate the corrosive and cause an unexpected high rate of attack.

Ultimate economic cost of a corrosion-resistant casting is related to its service life and freedom from breakdown as well as to its first cost. When adequate mechanical properties can be obtained with either of two alloys, long-range economy often dictates selection of the grade having superior corrosion resistance even though it may be more expensive. Influence of composition on alloy cost is shown in *Fig.* 4, but it must be recognized that this relationship is not invariant for every casting design.

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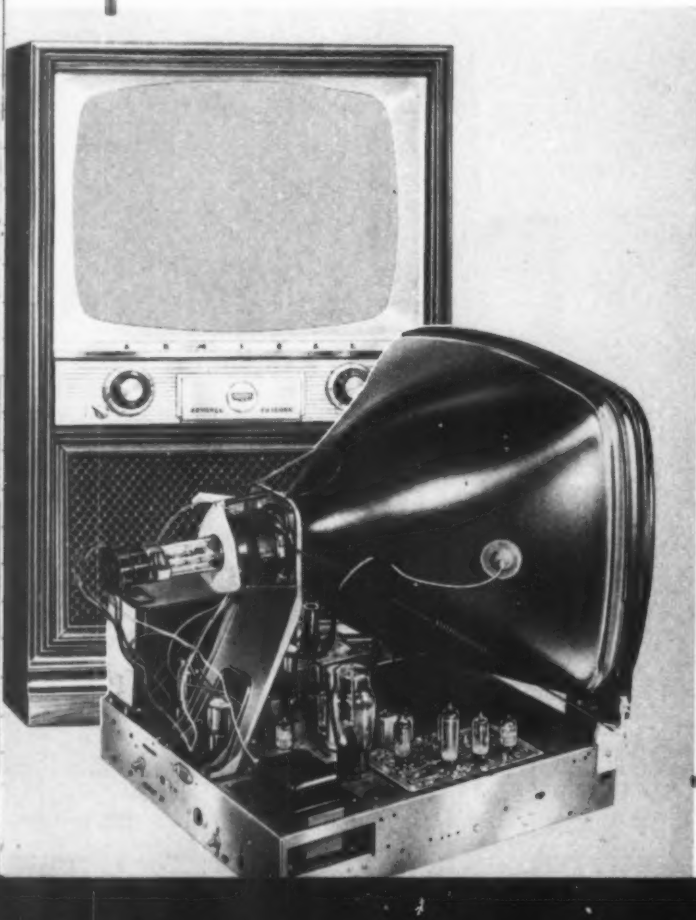
CONTEMPORARY DESIGN

TV Set Uses Printed Circuit



FIRST television chassis ever built using a printed circuit appears in the 1955 line of Admiral Corp. TV sets. Six tubes and one-third of all the normally exposed chassis wiring have been incorporated into the printed circuit. Sensitized copper plates are used for photoetching of the circuit. When all components, such as resistors, transformers and condensers, have been assembled to the etched plate, molten solder pot to complete the assembly. Use of the printed circuit will help to eliminate set malfunction due to vibration and make better quality control in production possible.

Transactions of The Second Conference on MECHANISMS

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Transactions of The Second Conference

Cam Design and Manufacture

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EARLY stages of the Industrial Revolution were marked by rapid development of a geometrical or design approach to mechanisms. This was accomplished not on a formal basis but, rather, on an intuitive basis. The resulting tremendous growth occupied the whole attention of the engineering world for many years.

We are entering a second phase in which emphasis is upon refinement and more explicit statement of the basic principles behind mechanisms. In this period of refinement sophistication of mathematical technique has increased.

Derivation of motion from cams is an apt illustration of the foregoing. Also a basis for bridging the gap which may exist between the people schooled in the earlier methods and those now working in the advanced regions of design will be suggested.

It was not generally appreciated by earlier designers that the cam had two functions: (1) To control space-time relationships of the machine and (2) To supply power in the machine. Since use of the cam under the restriction of the dual function severely limited its range of application, let us consider these functions separately.

A cam, or a group of cams, represents an information storage system of superior characteristics. Since the cam surface may be continuous, the storage density can be very high, comparing favorably with any other in common use. A check at MIT on comparative storage densities between a three-dimensional value analog cam and "Whirlwind's" entire memory capacities demonstrated a ratio of over three to one in favor of the single cam. The permanence of stored information is of a high order and, where a random entry in the memory is not desired, the cam offers the designer an excellent solution to the input problem.

On the other side, the cam does not appear in as favorable a light. As a source of power it has serious limitations. Consider the general problem of moving a mass with a cam. If the cam is to act in two directions, it must have two controlling surfaces, i.e., a grooved cam or complementary cams. It can be simplified by using a spring to keep the follower in contact with the cam but then, evidently, the spring supplies the power in one direction and the cam has the duty of loading the spring added to that of moving the mass in the other direction.

Considerations of positive control often lead to the adoption of cam and lever systems which prove to have cumulative deflections representing major phase shifts between input and output. Since these deflections are proportionate to the mass-acceleration characteristics, additions of mass to the transmission apparatus tend to defeat the purpose behind the additions. Rather, an examination of the system to try to lower its compliance is in order.

A more sophisticated approach will often demonstrate that better response characteristics can be had by using the cam system as a memory and signal output device which controls suitable power amplifiers. The simplification of arrangement and ability to work at very highpower levels will often make this approach more feasible from an economic point of view.

Gun-direction computers are excellent examples of such an arrangement. Here, tables of trigonometric functions, correction functions, and other functions are neatly packaged in the form of cams or noncircular gears and the system output is fed to servo-amplifiers which control gun co-ordinators so accurately that a significant proportion of the batteries' output passes through the critical target area at distances of 40,000 feet or more. Visualize such a system where the power is derived directly from the cams. Its physical size and arrangement would so restrict the system that its utility would be gone, assuming that it would work at all.

If, then, there are degrees of complexity where systems of more elaborate nature are required, logically there must be a more or less definite cross-over point beyond which the amplifier systems should be required. Indefinite as this point may be, much of present-day equipment in manufacturing and processing would be found wanting and ripe for redesign if an accurate analysis were made.

If the present-day refinement of method is to be continued and carried forward and the techniques from which these methods are presently

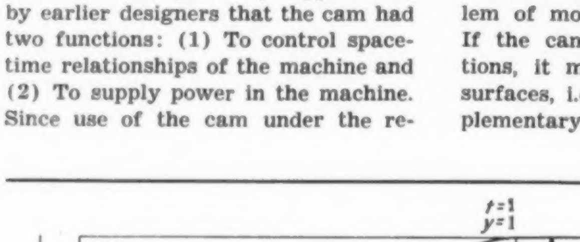

Fig. 1—General shape of follower displacement-time curve to meet specified conditions

on MECHANISMS

derived are beyond the reach of the majority of designers, there is a problem of developing approaches which can be used by the average designer and do not involve his complete re-education. As background, let us derive a typical motion funtion by techniques in common use now. Consider these specifications:

A cam is to cause the displacement of a mass.
The mass at times $t = 0$ and $t = 0 - \Delta t$ will be at rest.
The mass at time $t = 1$ and $t = 1 + \Delta t$ will be at rest.
The motion equation will be symmetrical about the point $t = \frac{1}{2}$.
There are no other specific requirements.

The "unity" displacement-time curve will resemble ***Fig.* 1**. Assume that we can find reason, in the system dynamics, for examining and controlling the motion equation and its first four derivatives. Since we specified a system at rest some time before and after the arbitrary unit time interval, our equation should conform to these conditions:

Displacement at $t = 0$ is 0, at $t = 1$ is 1
Velocity at $t = 0$ is 0, at $t = 1$ is 0
Acceleration at $t = 0$ is 0, at $t = 1$ is 0
Jerk at $t = 0$ is 0, at $t = 1$ is 0
4th derivative at $t = 0$ is 0, at $t = 1$ is 0

With such a system of five equations, which is symmetrical about $t = \frac{1}{2}$, we need only examine the acceleration curve to determine that it must have three roots at $t = 0$, three at $t = 1$, and one at $t = \frac{1}{2}$. The acceleration equation may therefore be written

$$\frac{d^2y}{dt^2} = k\,(t^3)\,(t-1)^3\,(2t-1)$$

$$= k\,(2t^7 - 7t^6 + 9t^5 - 5t^4 + t^3)$$

Integrating twice, with dy/dt and y each equal to zero when t is zero, the equation for displacement is

$$y = 70t^9 - 315t^8 + 540t^7 - 420t^6 + 126t^5$$

the value of k being 2520. This derivation represents only a single set of conditions and assumptions and is given for its simplicity and because it is in the literature. It leaves us

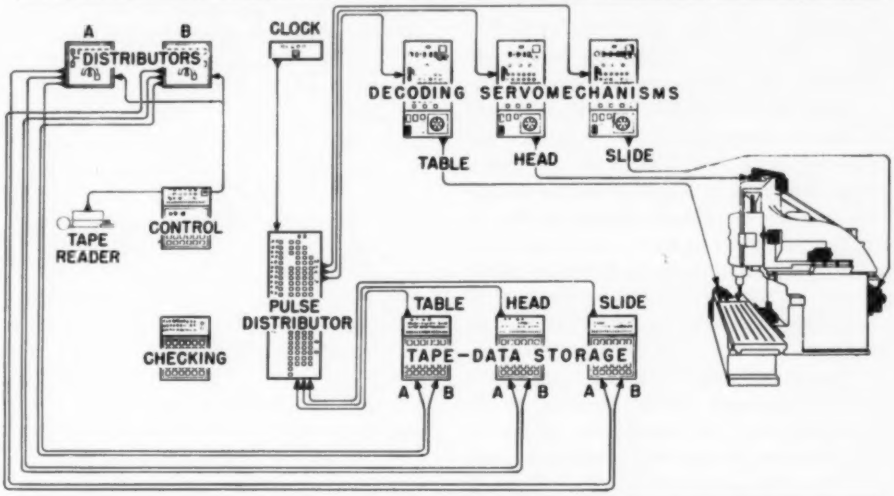

Fig. 2—Block diagram of system for controlling MIT digitally programmed milling machine, which has been used to make master cams to an equation

with the question, "What do we do with it?" The problem of translating this superior curve from paper to metal still remains.

Partial solutions are offered through several manufacturing techniques. Relatively accurate cams have been made on jig grinders using a large number of co-ordinate pairs. This method is far from a high-production method and is inordinately expensive. Cams made with copying devices do not present a general solution as they merely beg the question as to the source and quality of the master cam. These devices logically should follow the development of the means of producing highly accurate master cams. The equation given above has been used to make master cams using the MIT digitally programmed milling machine, ***Fig.* 2**.

However, in practice, this method proved to be severely limited. The surface finish was not satisfactory and, while the input-machine organization can be rearranged to program over as small intervals as desired, the refinement of the machine itself cannot be guided much beyond the present situation without considerable redesign.

Let us try now to bridge the gap between intuitive geometry and analytical mathematics. If, for convenience, a motion curve is plotted in rectangular co-ordinates, using an ar-

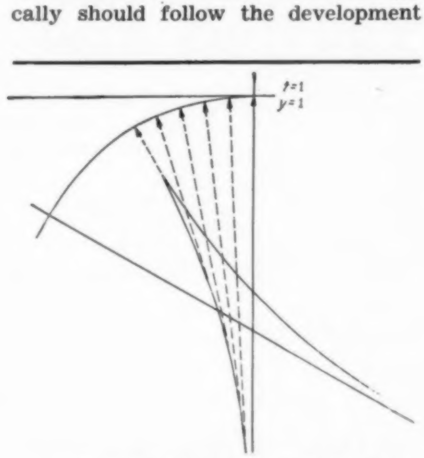

Fig. 3—Above—Locus of the center of curvature of the upper half of the curve in *Fig.* 1

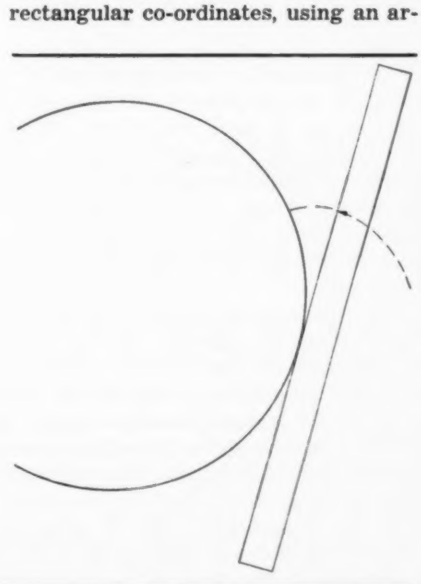

Fig. 4—Right—Generation of an involute with a straightedge rolled on a base circle

bitrary unit displacement plotted against an arbitrary unit time, it will appear as shown in *Fig.* 1.

Consider the case where, in the time preceding and following the unit time, the follower velocity is zero. Then the radius of curvature of these portions is infinite. If the cam portion is to blend perfectly into these portions, it must also approach infinite radius of curvature as it approaches the blend points, *Fig.* 1.

Now, if the curve is symmetrical about $t = \frac{1}{2}$, $y = \frac{1}{2}$, we need consider only half of the curve, and plotting the locus of center of curvature gives a curve such as shown in *Fig.* 3.

The ordinate at $t = 1$ is an asymptote and the normal to the maximum slope is the other, if the radius of curvature at this point is taken as infinite.

Successive radii of curvature are indicated, from the minimum at the cusp of the two-branched locus to the maximum of infinity as we approach the asymptote at $t = 1$. It now becomes apparent that the motion curve may be an involute developed from the locus as an evolute; the proof that this is a necessary condition need not be given here.

For many years, an accepted and highly practical technique of generating involutes to a circle has been to roll a straightedge on a base roll so that a generating tool or grinding wheel fixed to the straightedge has the required motion, *Fig.* 4.

This procedure may be adapted to the noncircular evolute in *Fig.* 3 but mechanically it is awkward to roll the straightedge from one branch of the evolute to the other, and it is natural to seek a more manageable technique.

Such a technique may be developed from the following consideration. If two points on the generating straightedge are moving at some instant in the same direction and with the same velocity, then the bar as a whole is rotating about a center infinitely distant. In the present case, this condition exists at each asymptote. If we are able mechanically to cause two points on the straightedge to move in such a manner, or at least a close approximation to it, we have fulfilled the boundary conditions on the motion curve.

The straightedge or generating line is seen in one position in *Fig.* 5. It is evident that the involute itself describes the motion specified for one point. A typical second point is shown, and its path of motion by the dashed line. We now suggest that the motions of the two control points on the generating line be obtained from linkages and answer the objection that if one point is on the involute itself, then why bother with the second?

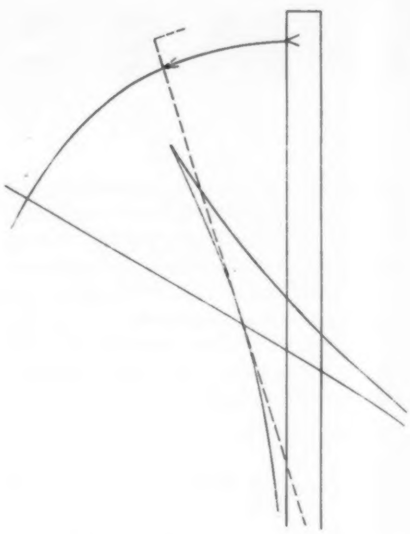

Fig. 5—Right—Straightedge or generating line rolling on an evolute which is the locus of centers of curvature

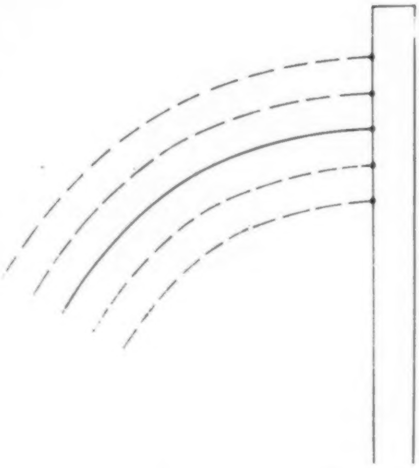

Fig. 6 — Below — Family of involute curves generated by several points on generating line

If a linkage is to generate directly a close approximation of the desired curve, the problem of determining the linkage dimensions is difficult and one curve only may be generated with any assurance of a good approximation. However, all points on the generating line generate parallel involutes so that a family of curves is available, *Fig.* 6. Not only is the selection of linkage dimensions simplified but a generating mechanism of considerable flexibility may be developed. Moreover, the flexibility may be further increased by providing means for rotating the system as a whole, while generating, to change the maximum involute slope at $t = \frac{1}{2}$, $y = \frac{1}{2}$.

Time and space do not permit developing this subject further to bring out some of the extremely interesting possibilities and techniques which open up. Those who are interested will be able to go a great deal further with considerable profit. These techniques have actually been applied on a laboratory scale with extremely encouraging success.

Vibration Analysis of Cams

By C. N. Neklutin
Vice President
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St. Louis, Mo.

WORK on cams for automatic machines was started at Universal Match Corp. in 1929. It was based on two ideas:

1. The shape of the cam should be determined from a selected acceleration diagram, but not vice versa, as was the practice at that time.

2. An instantaneous variation of the acceleration or an abrupt change in dynamic forces is undesirable. At that time it was known that an instantaneous application of a force produces stresses higher than the stresses created by the same forces applied statically. It was natural to suspect that a momentary unbalance between the applied force and the re-

CAM DESIGN

action to it from stresses would produce vibrations.

Many acceleration diagrams were analyzed. Cams were calculated from some of them, built, and used on automatic machines. Results were gratifying—machines were speeded up, efficiency and quality improved and, as a result, we reached a good competitive position in our industry. Nevertheless, we continued our search for better diagrams because of requests for higher and higher speeds.

During the original analysis of diagrams, we discovered that each diagram has a maximum which can be expressed as a dimensionless coefficient. Eventually it was designated as a maximum *acceleration coefficient*, and it became an important tool in evaluating the various diagrams for cams and for other mechanisms. The same was done with velocity diagrams, and maximum *velocity coefficients* were determined for every diagram. Later on, we found a very good use for these coefficients, especially for solving unusual problems. *Fig.* 1 explains the meaning of coefficients.

Sine-curve acceleration (sometimes called "cycloidal") appeared to be the most desirable form so far as a gradual change of inertia force is concerned. Unfortunately, the high value of the maximum acceleration was undesirable and our experience with some cams confirmed that. They required heavy springs to keep the cam follower on the cam surface, and when a heavy mass or a long flimsy bar was moved, the stresses became objectionable.

A trapezoid diagram was considered, but the main objection to it was in the low rate of increase of acceleration. Displacement at the start and at the end of the stroke was so small that it was difficult to reproduce tables of displacement on cam-cutting equipment.

Then an attempt was made to retain, to a certain extent, the characteristics of sine curve acceleration and to decrease the maximum acceleration coefficient.

So eventually a modified trapezoid diagram was created where straight lines were replaced by sine quadrants and, later, a group of diagrams was developed to cover all requirements. *Fig.* 1 shows a trapezoid diagram and the group of diagrams using quadrants of sine curves instead of straight lines.

All diagrams shown in *Fig.* 1 have equal periods for acceleration and for deceleration, and we describe them as "symmetrical" diagrams. Original cams were built with $b = 0.15$, *Fig.* 1, in order to keep the maximum acceleration coefficient closer to 4, which is a possible minimum. It was found experimentally that higher speeds (over 300 rpm) require a longer period of changing force, so that $b = 0.25$ was selected and is in use now in the great majority of cases. It means that in a symmetrical diagram the acceleration changes from zero to maximum during ⅛ of the total time of one stroke.

As the speed of cams was increasing under the pressure of competition, it became necessary to appraise the influence of vibrational stresses. Therefore, an extensive analysis was undertaken with emphasis on stresses after the stroke.

The reason was that residual vibrational stresses may affect the stresses during the next stroke—unless they are small or effectively

Fig. 1—Definition of terms and basic types of diagrams

INERTIA FORCE = MASS X ACCELERATION

When mass = unity, force and acceleration become synonymous.

In the case of cams the acceleration can be expressed in the form

$$A = \frac{S}{T^2} \times f(t)$$

S = stroke of cam in radians or inches
T = time of stroke in seconds
$f(t)$ = function of time (t) which varies from 0 to T

For cams $T = \dfrac{\alpha^\circ}{360} \times \dfrac{1}{N}$ SEC.

α° = angle on which cam rotates during a stroke in degrees
N = speed of cam in r.p.s.

The expression S/T^2 has measurements in inches/sec^2 or in radians/sec^2 or in the same measurements as the acceleration, therefore $f(t)$ is dimensionless. It has certain ± maximum values which are designated as

C_A = maximum acceleration coefficient $= A_{MAX} \Big/ \dfrac{S}{T^2}$

C_D = maximum deceleration coefficient $= D_{MAX} \Big/ \dfrac{S}{T^2}$

GRAVITY OR UNIFORM ACCELERATION has the lowest possible maximum acceleration coefficient,

$$C_A = C_D = 4.000$$

SINE CURVE ACCELERATION is relatively vibration free--has higher maximum acceleration coefficient,

$$C_A = C_D = 2\pi = 6.283$$

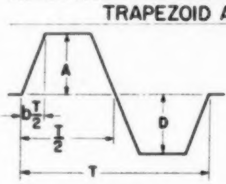
VELOCITY can be expressed in a similiar way

$$V = \frac{S}{T} f_V(t)$$

The maximum velocity coefficient is equal to the maximum value of $f_V(t)$

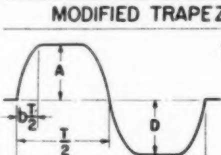
$$C_V = \frac{V_{MAX}}{S/T}$$ where $\dfrac{S}{T}$ is average velocity.

TRAPEZOID ACCELERATION DIAGRAM



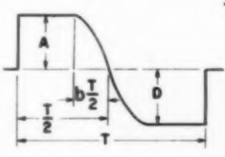
b	.0	.15	.25	.35	.5
$C_A = C_D$	4.00	4.71	5.33	6.15	8.00

MODIFIED TRAPEZOID ACCELERATION DIAGRAMS



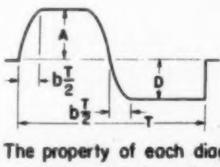
TYPE I– Stroke has dwell on both ends.

b	.0	.15	.25	.35	.5
$C_A = C_D$	4.0	4.49	4.89	5.36	6.28



TYPE II No dwells at the change of direction.

b	.0	.15	.25	.35	.5
$C_A = C_D$	4.0	4.02	4.05	4.10	4.20



TYPE III Stroke starts from a dwell, but there is no dwell between forward and return strokes.

b	.0	.15	.25	.35	.5
C_A	4.0	4.37	4.68	5.07	5.81
C_D	4.0	4.12	4.22	4.33	4.52

The property of each diagram depends on the parameter "b" which is a fraction of the acceleration or deceleration period during which the magnitude changes between 0 and maximum WHEN b=0 all diagrams change to UNIFORM ACCELERATION diagrams.

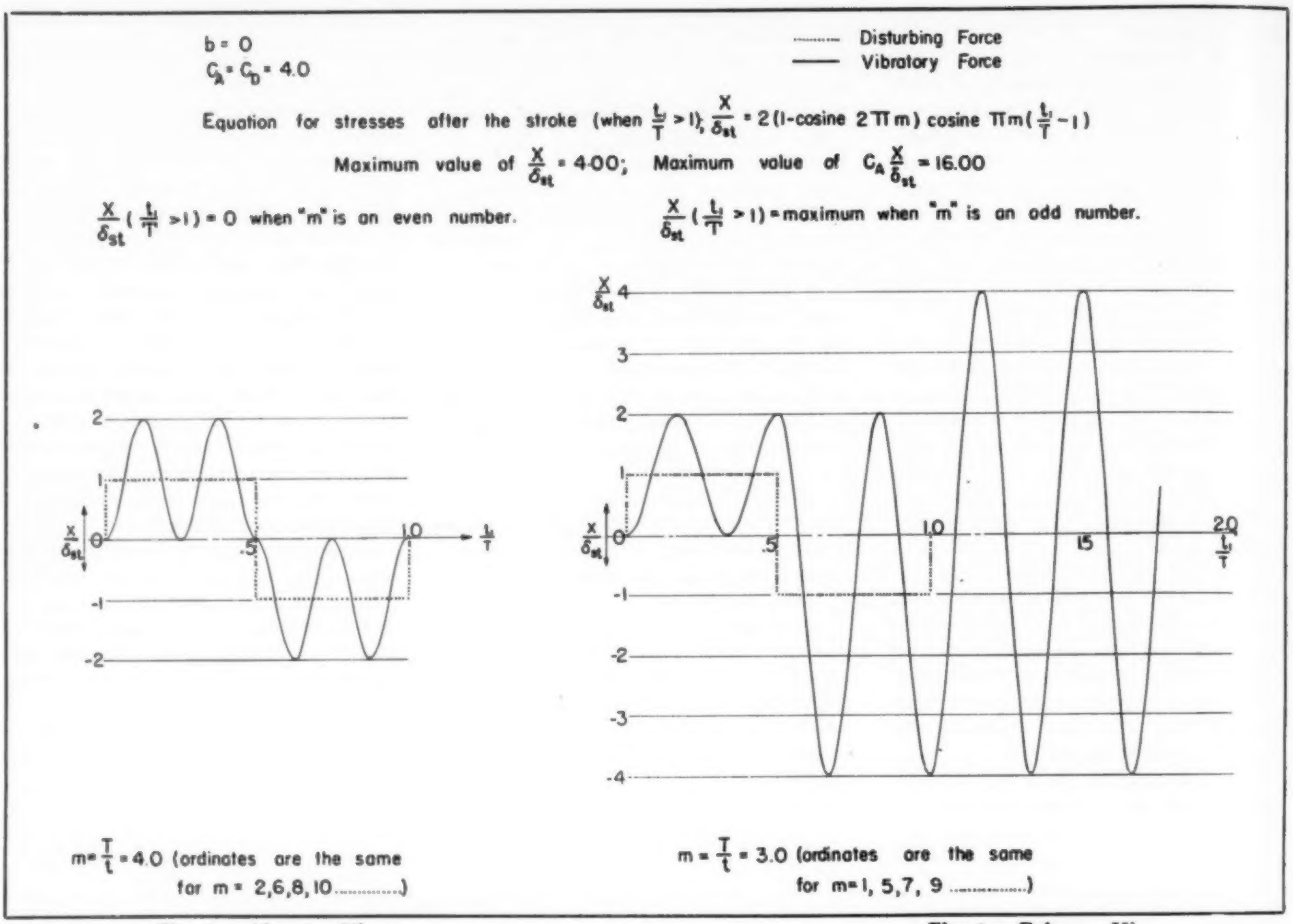
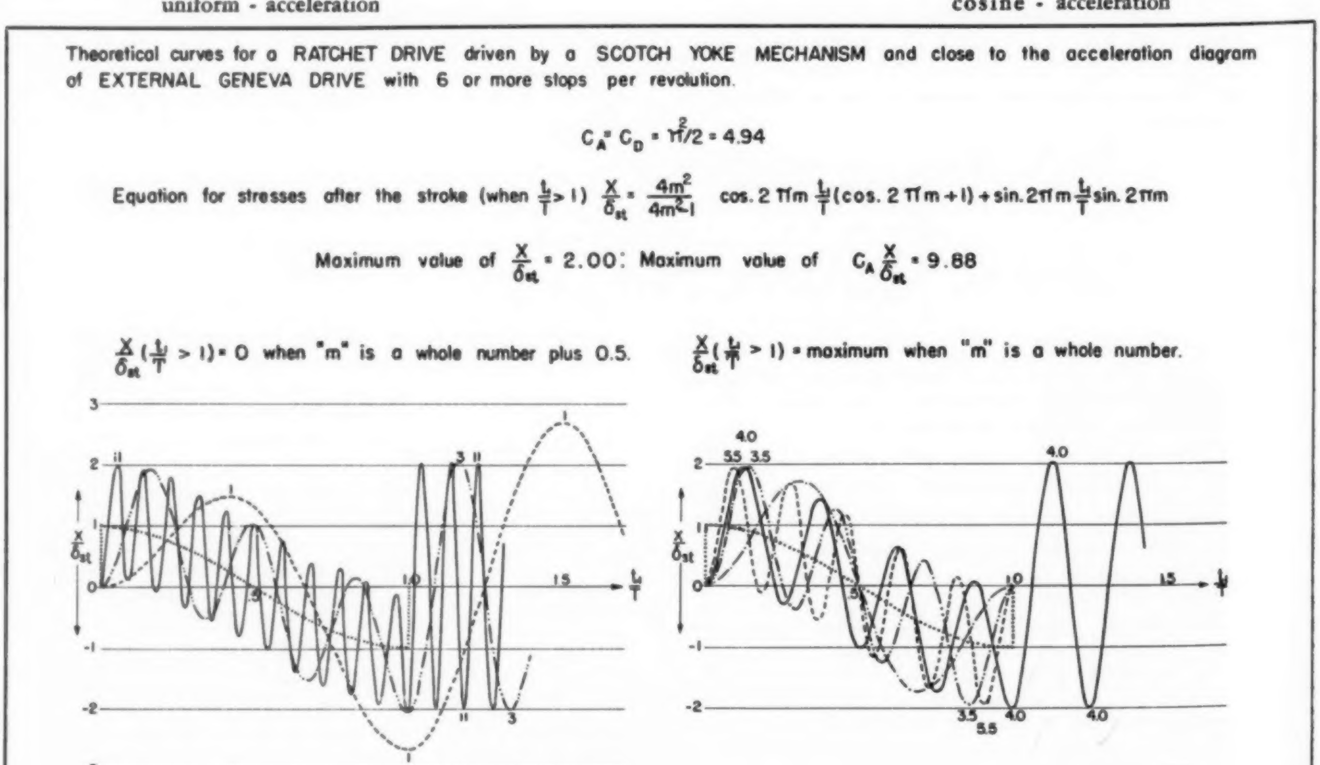


Fig. 2 — Above — Vibratory forces for uniform - acceleration

Fig. 3 — Below — Vibratory forces for cosine - acceleration



Triangular Acceleration with abrupt change at start and end of stroke.

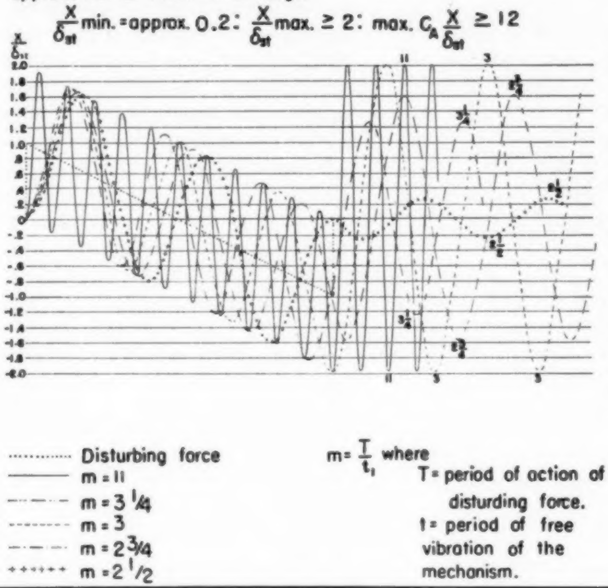
It is similar to the acceleration of the INTERNAL GENEVA DRIVE, but has lower maximum acceleration.

$$C_A = C_D = 6$$

Equation for stresses after the stroke (when $\frac{t_1}{T} > 1$): $\frac{X}{\delta_{st}} = \sin 2\pi m \frac{t_1}{T} \times \left[\frac{1}{\pi m}(1-\cos 2\pi m) - \sin 2\pi m\right] - \cos 2\pi m \frac{t_1}{T}\left[(1+\cos 2\pi m) - \frac{1}{\pi m}\sin 2\pi m\right]$

High maximum value of this expression is always greater than zero. The maximum stresses appear when "m" is close to a full number, then the ratio X/δ_{st} is >2 when "m" is small and it approaches 2 when "m" is large.

$$\frac{X}{\delta_{st}}\text{min.} = \text{approx. } 0.2 : \frac{X}{\delta_{st}}\text{max.} \geq 2 : \text{max. } C_A \frac{X}{\delta_{st}} \geq 12$$



Triangular Acceleration with abrupt change in the middle of the stroke.

It is similar to the acceleration of the EXTERNAL GENEVA DRIVE with 3 and 4 stops per revolution and to ELLIPTICAL GEARS.

$$C_A = C_D = 12$$

Equation for stresses after stroke (when $\frac{t_1}{T} > 1$): $\frac{X}{\delta_{st}} = 2(1 - \frac{1}{\pi m}\sin \pi m) \times (\cos 2\pi m \frac{t_1}{T} \cos \pi m + \sin 2\pi m \frac{t_1}{T} \sin \pi m)$.

The maximum vibrational stresses are always greater than zero.

$$\frac{X}{\delta_{st}} \geq 2 : C_A \frac{X}{\delta_{st}} \geq 24$$

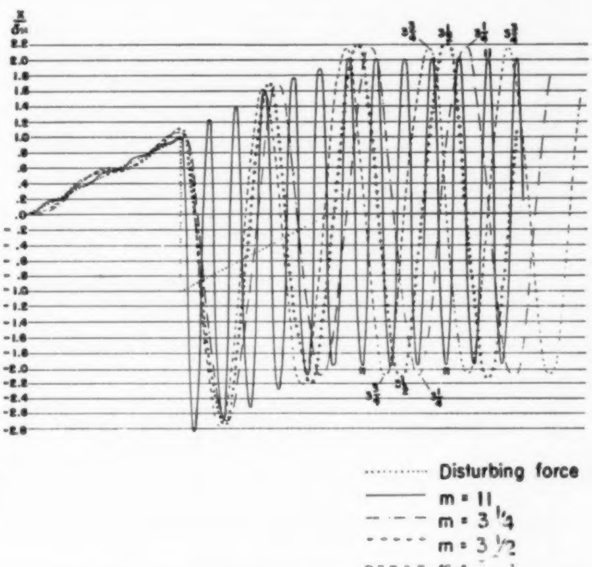


Fig. 4 — Above — Vibratory forces for triangular-acceleration

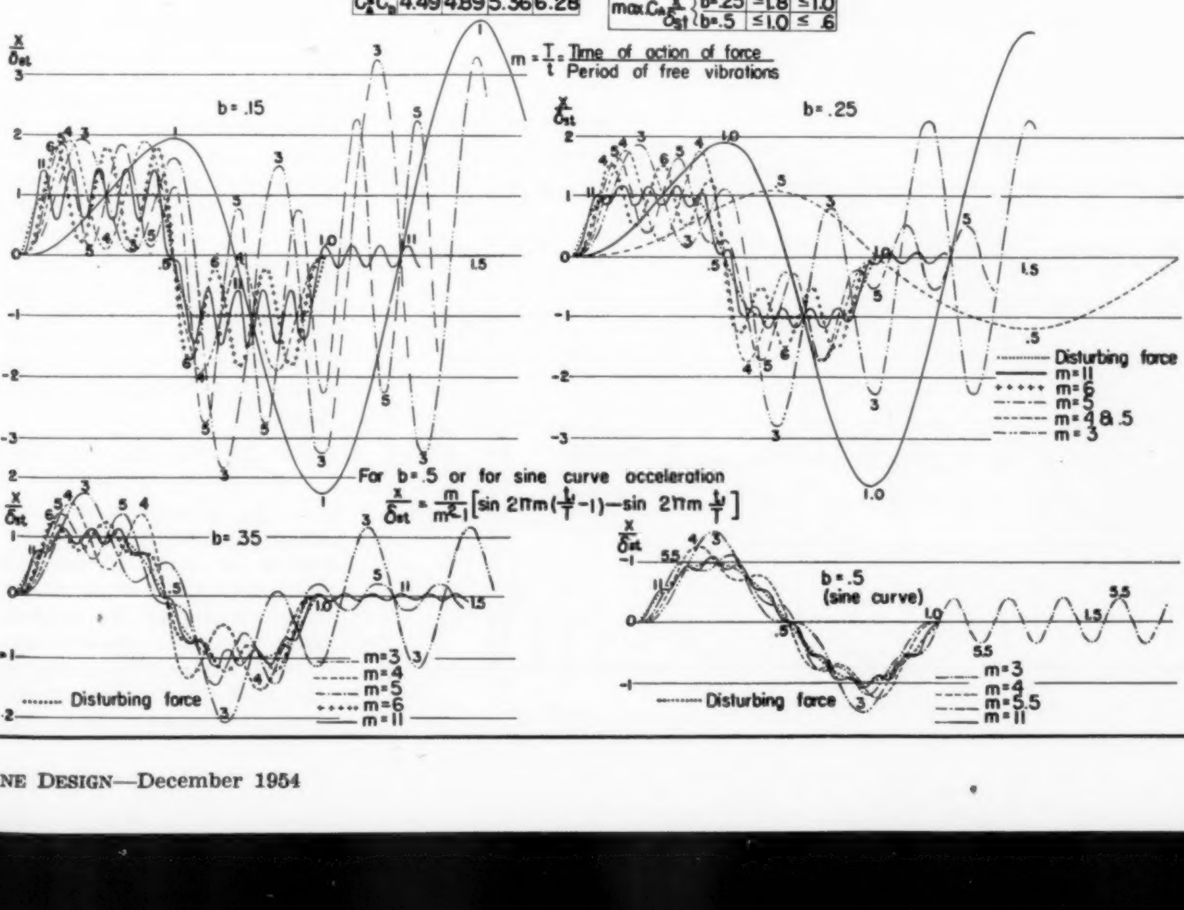
Fig. 5 — Below — Vibratory forces for modified-trapezoid acceleration

Equation for stresses after the stroke (when $\frac{t_1}{T} > 1$)

$$\frac{X}{\delta_{st}} = \frac{1}{(2bm)^2 - 1} \times \left\{\sin 2\pi m \frac{t_1}{T}\left[\sin b\pi m - \sin(1-b)\pi m - \sin(1+b)\pi m + \sin(2-b)\pi m - 2bm(1-\cos 2\pi m)\right] + \cos 2\pi m \frac{t_1}{T}\left[\cos b\pi m - \cos(1-b)\pi m - \cos(1+b)\pi m + \cos(2-b)\pi m - 2bm \sin 2\pi m\right]\right\}$$

b	.15	.25	.35	.5
$C_A = C_D$	4.49	4.89	5.36	6.28

	$m \geq$	12	20
$\max C_A \frac{X}{\delta_{st}}$	b = .25	≤ 1.8	≤ 1.0
	b = .5	≤ 1.0	≤ .6



For b = .5 or for sine curve acceleration

$$\frac{x}{\delta_{st}} = \frac{m}{m^2 - 1}\left[\sin 2\pi m\left(\frac{t_1}{T} - 1\right) - \sin 2\pi m \frac{t_1}{T}\right]$$

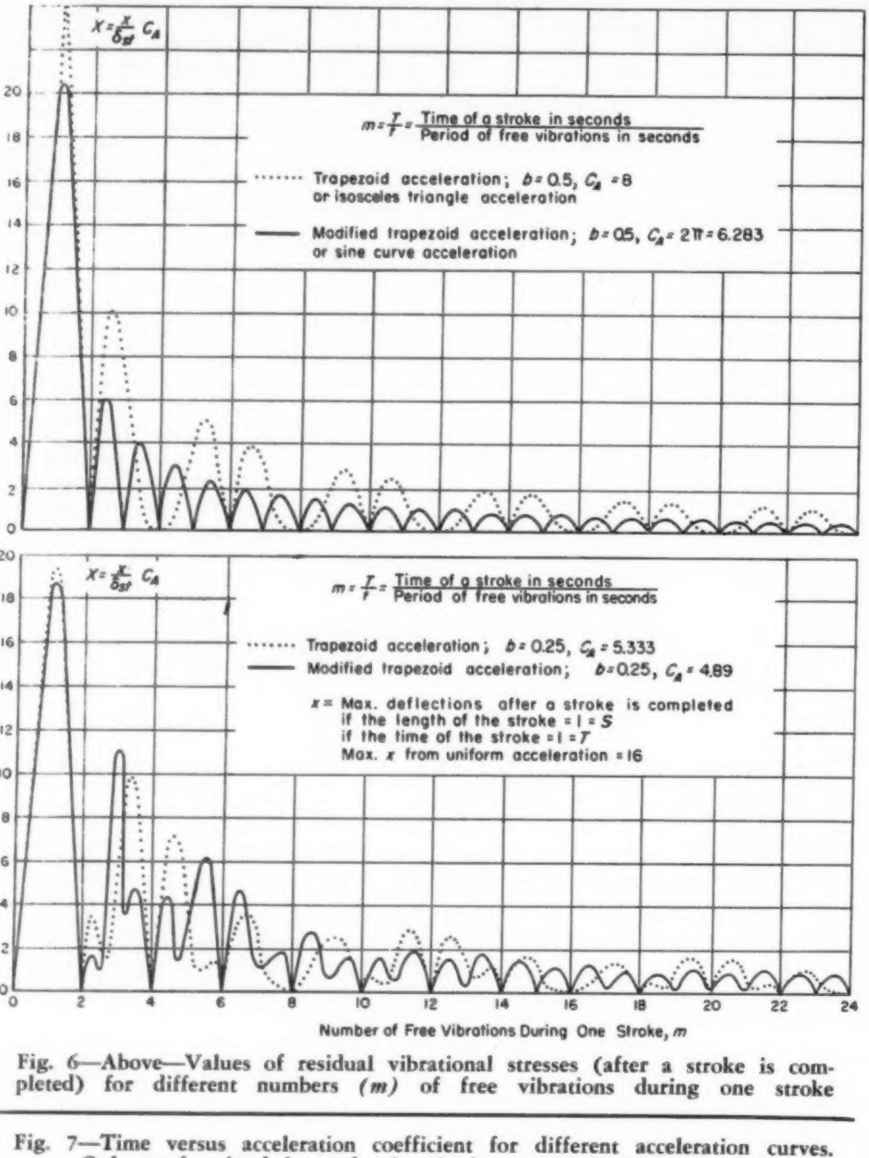
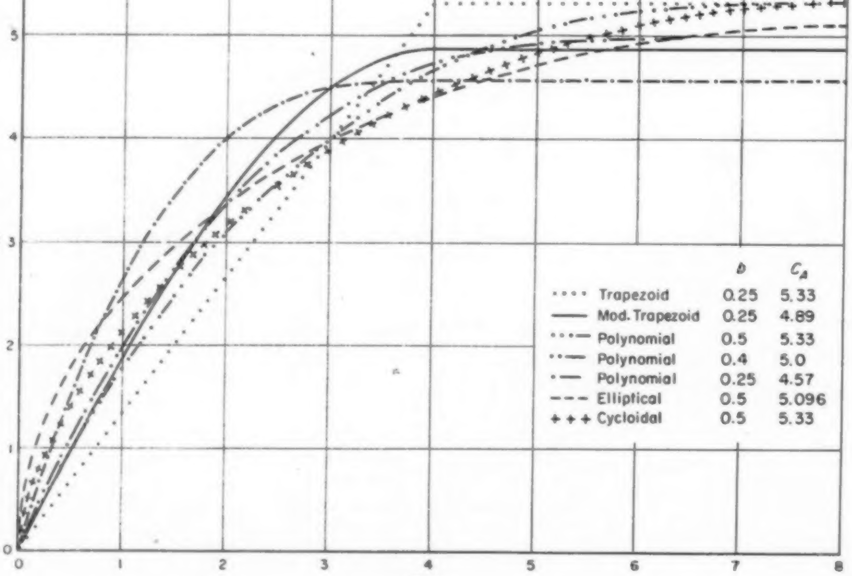


Fig. 6—Above—Values of residual vibrational stresses (after a stroke is completed) for different numbers *(m)* of free vibrations during one stroke

Fig. 7—Time versus acceleration coefficient for different acceleration curves. Only one-fourth of the stroke time is shown; curves are symmetrical



damped. That fact is important in high-speed machines where vibratory stresses are quite significant, the time between strokes is exceedingly small and the use of damping devices (except friction) is difficult.

Comparison of Vibrational Stresses: The analysis of vibrational stresses was made for acceleration diagrams which could be analyzed easily. Some of them allow conclusions about similar diagrams of some mechanisms widely used on automatic machines. This approach was used because the acceleration diagrams of these mechanisms are expressed by complicated equations difficult to integrate or requiring long and tedious work.

Two types of charts will be presented. In the first group the dynamic stresses are shown during the stroke and after it is completed, and the charts show the variations of stresses as they occur, *Figs.* 2 to 6.

They are compared with static stresses which would be produced if the dynamic force is applied statically. And the static stress created by the maximum acceleration is taken as unity. The ordinates of the charts show the ratio between the dynamic stress at any moment, designated as x, and the maximum stress δ_{st}, produced by the maximum force acting during the stroke but applied statically. These charts permit an appraisal, in some cases, of the reasons for unfavorable stresses.

Each curve on the charts represents dynamic stresses for a certain number of free vibrations of the driven mechanism which occur during the stroke; this number is designated as m.

The main purpose of the charts was to study the influence of the presence or absence of abrupt variation of acceleration on vibrational stresses. The latter are presented as a ratio, x/δ_{st}, where δ_{st} is unity; it can be replaced by the maximum acceleration coefficient for each diagram. The result will give the value of vibrational stresses proportional to the force created by a mass = 1, moving during one second on a distance (stroke) = 1. Therefore, the expression, $C_A\,(x/\delta_{st})$, permits the comparison of different acceleration diagrams.

The following observations can be made from *Figs.* 2, 3 and 4:

1. The number of free vibrations during the stroke time is an important factor except in case of the diagram with one abrupt change of acceleration during the stroke; it has high vibrational stresses always. A physical explanation of this might be that since the abrupt variation in the applied force occurs only once, there

is no possibility of counteraction or "canceling out" by a second abrupt variation.

2. The acceleration diagrams with two and three abrupt changes of acceleration have no residual vibrational stresses for a certain value of m; unfortunately, a slight variation of m increases the residual stresses to a maximum.

3. In all diagrams with an abrupt variation of acceleration, the ratio, x/δ_{st}, changes very little or not at all when m increases, because m either enters into trigonometric functions of sine and cosine types so that it cannot decrease the absolute value of them, or enters in a form which decreases stresses only slightly.

Observations which can be made from *Fig.* 5 are:

1. Diagrams without abrupt variations of acceleration have the maximum vibrational stresses decreasing with an increase of m. This leaves two ways to decrease residual vibrational stresses:

   a. Decreasing the weight of moving parts.
   b. Increasing the rigidity of the mechanism to increase the frequency of free vibrations of the system.

High frequency of vibration increases the number of cycles during the dwell period, so that a better damping can be expected due to internal friction (hysteresis).

2. To have reasonably low vibrational stresses in the modified trapezoid diagram, it is necessary to have more than one cycle of free vibration during the time the acceleration changes from zero to plus or minus maximum; in other words, for the diagram with $b = 0.25$, m should be more than 8.

It is evident that basically our work on cams was started in the right direction.

The next illustrations are devoted exclusively to comparative values of vibrational stresses *after a stroke is completed*. To make the charts clearer, only maximum stresses are shown. They are drawn as a function of the number of free vibrations, m, during one stroke. The reading of ordinates for any value of m shows the magnitude of maximum vibrational stresses which actually vary from plus maximum to minus maximum.

Fig. 6 shows the comparison of properties of the trapezoid diagram and the modified trapezoid with $b = 0.25$ and $b = 0.5$. In the latter case, the trapezoid diagram becomes an isoceles triangle and the modified diagram becomes a sine curve.

The results shown on *Fig.* 6 are favorable for the modified trapezoid; it appears to be a better diagram than the trapezoid.

Also, the results were upsetting because we, like many other people, assumed that a slower rate of change of force may be beneficial for decreasing vibrational stresses.

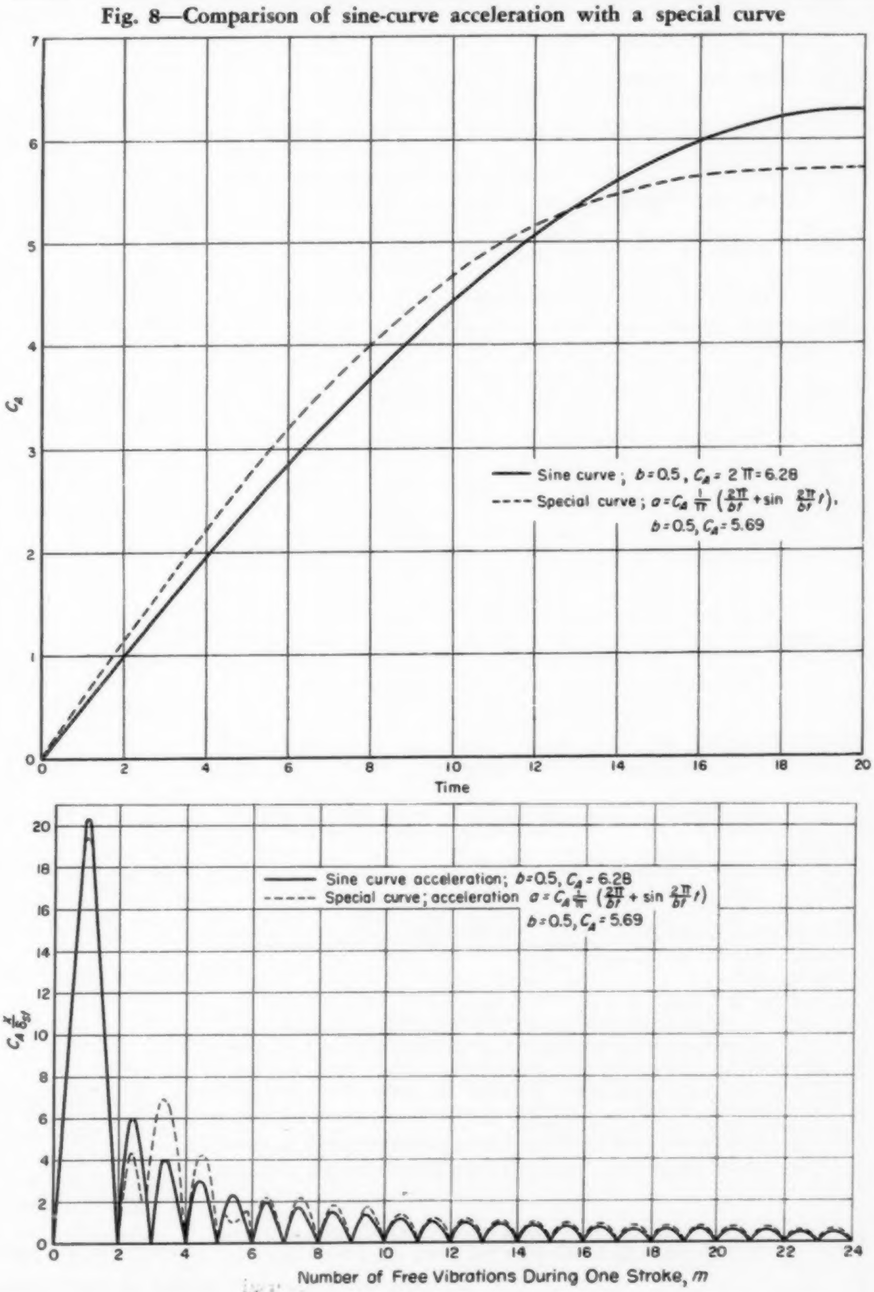
In this case, the sine curves appear to be better than the straight lines of the trapezoid. The only explanation may be that the higher rate of change of acceleration in the case of the sine curves is during the time when the acceleration is low.

We then started a search for a better diagram than the modified trapezoid on the assumption that a higher rate of change of acceleration when the acceleration is low would be beneficial.

As a limit in that direction, an elliptical diagram was selected. It has at the start a 90-degree tangent. This and other diagrams developed at this stage are shown in *Fig.* 7. The results were highly unsatisfactory—the vibrational stresses for $b = 0.5$ were many times higher than those from the modified trapezoid diagram with $b = 0.25$.

The next step was to find curves which lie between sine-curve quadrants and the elliptical curve. A polynomial equation was selected and three solutions were analyzed. One polynomial curve with $b = 0.5$ had a rate of change of acceleration slightly higher than that of the sine quadrants at the start and lower at

Fig. 8—Comparison of sine-curve acceleration with a special curve



SYMBOLS

S_A = Stroke during acceleration period
S_D = Stroke during deceleration period
$S_A + S_D$ = Total stroke = S
$\alpha_A = \alpha \frac{1}{1+P}$ = Angle of cam rotation during acceleration (time)
$\alpha_D = \alpha \frac{P}{1+P}$ = Angle of cam rotation during deceleration (time)
$\alpha_A + \alpha_D = \alpha$ = Working period of cam (time)
P = Deceleration period ÷ Acceleration period = $\frac{\alpha_A}{\alpha_D}$
α_A and α_D represents 60 divisions on corresponding unity table

The displacement in each unity table varies from 0 to 1.

To obtain the actual displacement for the acceleration period, multiply the displacement figures in the proper unity table by S_A.

To obtain the actual displacement for the deceleration period, multiply the displacement figures in the proper unity table by S_D and add the results to the maximum displacement at the end of the acceleration period.

The tables are designated by Roman Numerals I, II and III to indicate the type of diagram. The letter A or D after the Roman Numerals describes the table as for Acceleration or for Deceleration.

Six tables are necessary for each value of "b."

Tables for "b" = .25 are suitable for majority of cases

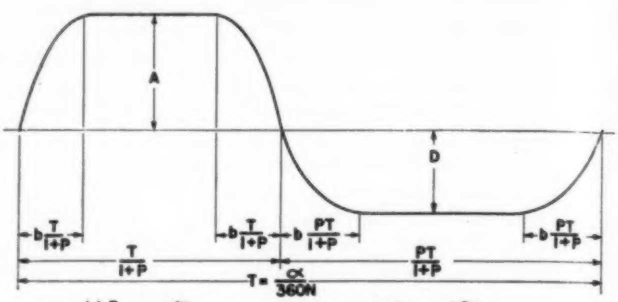
Tables for "b" = .15 may be useful, especially for moving large masses at low speeds.

Tables for "b" = .5 or higher for Diagram II........AND

Tables for "b" = .5 for Diagram I may be useful for high speeds and large masses.

DIAGRAM I

The stroke is performed between dwells.



$$C_A = \frac{1+P}{2} \times \frac{2\pi}{\frac{\pi}{2}-(\pi-2)b} \qquad C_D = \frac{1+P}{2P} \times \frac{2\pi}{\frac{\pi}{2}-(\pi-2)b} \qquad C_V = 2$$

$$A = C_A S \frac{1+P}{2}\left(\frac{360}{\alpha}N\right)^2 \qquad D = C_D S \frac{1+P}{2P}\left(\frac{360}{\alpha}N\right)^2 \qquad \frac{A}{D} = P$$

$$S_A = S\frac{1}{1+P}\ ;\ \alpha_A = \alpha\frac{1}{1+P} \qquad S_D = S\frac{P}{1+P}\ ;\ \alpha_D = \alpha\frac{P}{1+P}$$

When P = 1

b	.0	.15	.25	.35	.5
$C_A = C_D$	4.0	4.4698	4.8881	5.3646	6.2832

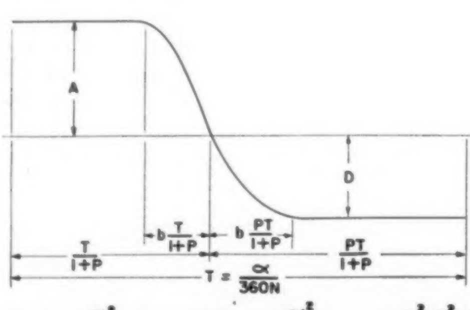
$= \frac{2\pi}{\frac{\pi}{2}-(\pi-2)b}$

b = .25

P		.2	.3333	.5	.75	1.0	1.25	1.5	2	3	4	5
C_A		2.933	3.259	3.666	4.277	4.888	5.499	6.110	7.332	9.776	12.220	14.664
C_D		14.664	9.776	7.332	5.703	4.888	4.399	4.073	3.666	3.259	3.055	2.933
$C_A \div C_D$		.2	.3333	.5	.75	1.0	1.25	1.5	2	3	4	5
$S_A \div S$ or $\alpha_A \div \alpha$		.8883	.75	.6667	.57143	.5	.4444	.4	.3333	.25	.2	.1667
$S_D \div S$ or $\alpha_D \div \alpha$		.1667	.25	.3333	.4286	.5	.5556	.6	.6667	.75	.8	.8333
for C_A & A	$\frac{1+P}{2}$	.6	.6667	.75	.875	1.0	1.125	1.25	1.5	2.0	2.5	3.0
C_D & D	$\frac{1+P}{2P}$	3.0	2.0	1.5	1.1667	1.0	.9	.8333	.75	.6667	.625	.6
S_A & α_A	$\frac{1}{1+P}$	.8333	.75	.6667	.57143	.5	.4444	.4	.3333	.25	.2	.1667
S_D & α_D	$\frac{P}{1+P}$	.1667	.25	.3333	.4286	.5	.5556	.6	.6667	.75	.8	.8333

DIAGRAM II

The movement is reversed without a dwell.



$$\frac{A}{D} = P;\quad C_A = (1+P)\frac{2\pi^2}{\pi^2-(\pi^2-8)b^2};\quad C_D = \frac{1+P}{P} \times \frac{2\pi^2}{\pi^2-(\pi^2-8)b^2};\quad E = \frac{\pi^2-(\pi^2-8)b^2}{\pi[\pi-(\pi-2)b]}$$

$$A = C_A S\frac{1+P}{2}\left(\frac{360}{\alpha}N\right)^2;\quad D = C_D S\frac{1+P}{2P}\left(\frac{360}{\alpha}N\right)^2;\quad C_V = 2\frac{\pi[\pi-(\pi-2)b]}{\pi^2-(\pi^2-8)b^2} = \frac{2}{E}$$

$$S_A = S\frac{1}{1+P};\quad \alpha_A = \alpha\frac{1}{1+P};\quad S_D = S\frac{P}{1+P};\quad \alpha_A = \alpha\frac{P}{1+P}$$

When P = 1

b	.0	.15	.25	.35	.5
$C_A = C_D$	4.0	4.0171	4.0479	4.0950	4.1988
C_V	2.0	1.8991	1.8401	1.7871	1.7180

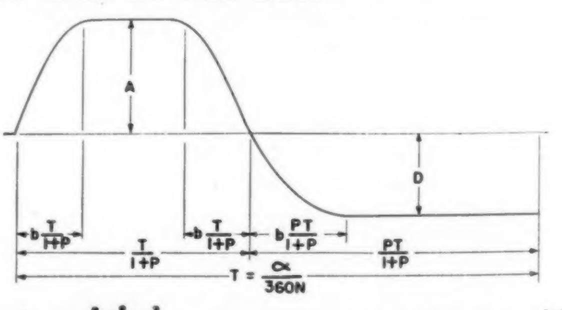
$= 2\frac{2\pi^2}{\pi^2-(\pi^2-8)b^2}$

$P \gtrless 1$ — For b = .15

P	.2	.3333	.5	.75	1.0	1.25	1.5	2	3	4	5
C_A	2.410	2.678	3.013	3.515	4.017	4.519	5.021	6.026	8.034	10.043	12.051
C_D	12.051	8.034	6.026	4.687	4.017	3.615	3.348	3.013	2.678	2.511	2.410
$S_A \div S$ or $\alpha_A \div \alpha$	.8333	.75	.6666	.57143	.5	.4444	.4	.3333	.25	.2	.1667
$S_D \div S$ or $\alpha_D \div \alpha$	.1667	.25	.3333	.4286	.5	.5556	.6	.6666	.75	.8	.8333
For b = .25											
C_A	2.429	2.699	3.036	3.542	4.048	4.554	5.060	6.072	8.096	10.120	12.144
C_D	12.144	8.096	6.072	4.723	4.048	3.643	3.373	3.036	2.699	2.530	2.429
For b = .5											
C_A	2.519	2.799	3.149	3.674	4.199	4.724	5.249	6.298	8.398	10.497	12.596
C_D	12.596	8.398	6.298	4.899	4.199	3.779	3.499	3.149	2.799	2.624	2.519

DIAGRAM III

The stroke starts from a dwell, but there is no dwell between forward and return strokes.



$$\frac{A}{D} = P\frac{G}{K};\quad E = \frac{\pi^2-(\pi^2-8)b^2}{\pi[\pi-(\pi-2)b]};\quad G = \pi-(\pi-2)b;\quad K = \pi-(\pi-2)2b;\quad C_V = 2\frac{1+P}{1+PE}$$

$$C_A = (1+P)^2\frac{2\pi}{K(1+PE)};\qquad C_D = \frac{(1+P)^2}{P} \times \frac{2\pi}{G(1+PE)}$$

$$A = C_A S\frac{2}{1+PE}\left(\frac{360}{\alpha} \times \frac{1+P}{2}\right)^2 N^2;\qquad D = C_D S\frac{2PE}{1+P}\left(\frac{360}{\alpha} \times \frac{1+P}{2P}\right)^2 N^2$$

$$S_A = S\frac{1}{1+PE};\quad \alpha_A = \alpha\frac{1}{1+P};\quad S_D = S\frac{PE}{1+PE};\quad \alpha_D = \alpha\frac{P}{1+P}$$

Auxiliary Table →

b	.0	.15	.25	.35	.5
E	1.0	1.05314	1.08690	1.11913	1.16416
G	3.14159	2.97035	2.85620	2.74204	2.57080
K	3.14159	2.79912	2.57080	2.34248	2.0
G ÷ K	1.0	1.06117	1.11102	1.17057	1.28540

When b = .25

P	.2	.3333	.5	.75	1.0	1.25	1.5	2	3	4	5
C_A	2.900	3.190	3.563	4.124	4.685	5.246	5.807	6.931	9.178	11.426	13.674
C_D	13.010	8.612	6.414	4.949	4.217	3.777	3.485	3.119	2.754	2.571	2.462
$C_A \div C_D$	.2222	.3703	.5555	.8333	1.1110	1.3888	1.6665	2.222	3.333	4.4441	5.5551
C_V	1.9714	1.9575	1.9437	1.9282	1.9167	1.9079	1.9009	1.8905	1.8776	1.870	1.8649
$S_A \div S$	.821	.734	.648	.551	.479	.424	.380	.315	.235	.187	.155
$S_D \div S$	.179	.266	.352	.449	.521	.576	.620	.685	.765	.813	.845

Fig. 9—"Universal" system of cam design

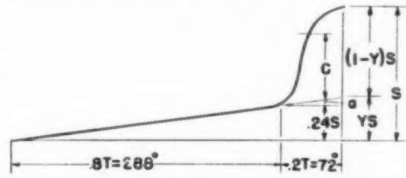
Requirements: (Example I)

Design a cam for a varying angular velocity movement – one revolution of the cam to be considered as one cycle.

24% of the stroke is produced at a constant velocity during 80% of the cycle time.

76% of the stroke should be made during 20% of the cycle time.

No dwell required.



Displacement Diagram

Solution: Make a table of displacement during the period with constant velocity.

Determine the displacement produced during the whole cycle by the constant velocity. It is equal to $YS = 0.24S \div 0.8 = 0.3S$ or $Y = 0.3$.

The displacement during the accelerated part of the cycle equals $(1-Y)S = .7S$

Multiply the unity tables for Diagram I by .7S and add to the results the displacement "a" produced by the constant velocity.

For Diagram I with "b" = .25, the acceleration coefficient $C_A = 4.89$.

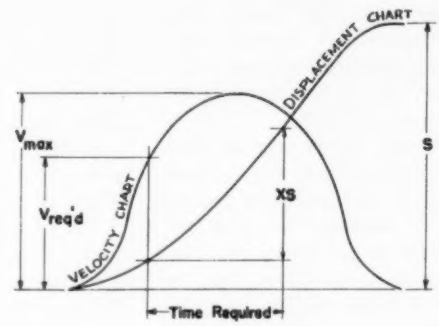
Maximum acceleration $A_{Max.} = 4.89 \times .7S\left(\frac{360°}{72°}N\right)^2$

Requirements: (Example II)

An intermittent motion should be produced.

A certain velocity should be reached:

After that moment a certain minimum displacement should be performed during a certain fraction of the cycle time.



Displacement and Velocity Diagrams

Solution: A symmetrical acceleration (Diagram I) was tried and it gave a satisfactory solution.

If this had not been a satisfactory solution it would then have become necessary to try nonsymmetrical diagrams with $P \gtrless 1$.

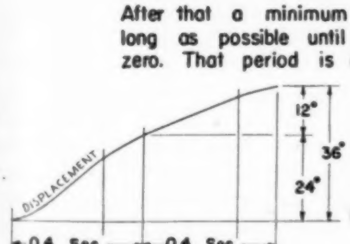
Then only time is necessary to find the solution as displacement tables are available and only the parameter "P" should be introduced.

Requirements: (Example III)

The driven part should rotate on 36° per cycle.

The first 24° of the movement should be accomplished in 0.4 second.

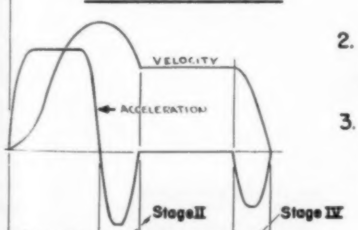
After that a minimum speed is maintained as long as possible until it is brought down to zero. That period is also 0.4 second.



Displacement Diagram

Our Requirements

1. The velocity at the end of stage I is equal to the velocity at the beginning of stage II.
2. The velocity at the beginning of stage IV is equal to constant velocity.
3. The acceleration during stage I should be equal to deceleration during stages II and IV.



Acceleration and Velocity Diagrams

Equations: (1) $t_1+t_2=0.4$ sec. (2) $t_3+t_4=0.4$ sec. (3) $S_1+S_2=24°$

(4) $S_3+S_4=12°$ (5) $S_2=V_c\,t_2+S_{20}$ (6) $C_v\frac{S_1}{t_1}=2\frac{S_2}{t_2}-V_c$ (7) $C_v\frac{S_4}{t_4}=V_c$

(8) $S_3=V_3 t_3$ (9) $\frac{S_1}{t_1^2}=\frac{S_2}{t_2^2}-\frac{V_c}{t_2}$ (10) $\frac{S_1}{t_1^2}=\frac{S_4}{t_4^2}$

10 equations and 10 unknowns: $t_1, t_2, t_3, t_4, S_1, S_2, S_3, S_4, S_{20}$, & V_c.

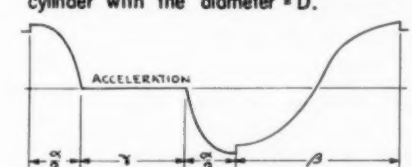
The knowledge of C_v established equations (6) and (7), so the problem can be solved.

Knowing C_A, the values of maximum acceleration can be found.

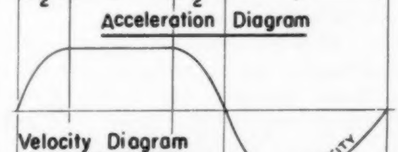
Requirements: (Example IV)

A reciprocating movement of a press bed should be produced.

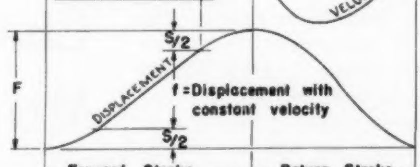
Acceleration and deceleration should be equal for both strokes. During the forward stroke there is a period of constant velocity equal to the peripheral velocity of a cylinder with the diameter = D.



Acceleration Diagram



Velocity Diagram



Displacement Diagram

Equations: (1) $\alpha+\beta+\gamma=360°$ (2) $\frac{\gamma}{360}=\frac{f}{\pi D}$ (3) $V_f=C_v S\frac{360}{\alpha}N=\pi DN$

(4) $C_A S\left(\frac{360}{\alpha}N\right)^2=C_A F\left(\frac{360}{\beta}\right)^2$. (5) $f+S=F$ (6) $\frac{d\,\alpha/N^2}{dt}=0$ to find minimum acceleration.

The knowledge of C_v establishes equation (3).

Fig. 10—Applications of "universal" cam design methods

the end of the change of acceleration. Vibrational stresses were practically identical with those of the modified trapezoid diagram with $b = 0.25$.

The other two solutions, with $b = 0.4$ and $b = 0.25$, gave curves located between the sine curve quadrants and the elliptical curve. The vibrational stresses are higher than in the case of sine curves and they are higher as the curve approaches the elliptical curve in form.

Then a cycloidal curve was plotted on the acceleration chart, *Fig.* 7, and it appears in the same region as the last polynomial curves. To date we have not found a practical solution for the vibration equations due to difficulties of integration, but we expect it to be in the same class as that of the polynomial curves with b smaller than 0.4.

Finally, we came to the conclusion that sine curves are about the best so far as the residual vibrational stresses are concerned and they are easy to handle mathematically.

But the search was not ended. Mr. E. G. Reader, manager of the Roller Gear Div., suggested the checking of another trigonometric function which has a slightly higher rate of change at the start than does our sine curves, *Fig.* 8. It was checked because a higher rate of change of acceleration at the start of the movement is more favorable for cutting cams.

We came to the conclusion that it is not favorable for general use, but it may be valuable for high speed with large masses because its acceleration coefficient is 5.69 as compared with 6.28 in the case of sine curve acceleration.

"Universal" System of Cam Calculations: It is evident from this discussion that we continue to favor the use of modified trapezoid acceleration, which is a combination of sine curve quadrants and of uniform acceleration. Such diagrams are described by discontinued equations; one diagram requires from four to six equations. But there are no discontinuities in the charts; the curve in one section of the diagram blends with the line in the next section.

The advantage of this group of diagrams for practical use is in the knowledge of acceleration and velocity coefficients which can be easily found after two ratios are selected.

One ratio is b, already mentioned many times. It is the fraction of the acceleration or of the deceleration period during which the force changes. The other is designated as p and represents the ratio of the deceleration time to the acceleration time.

The knowledge of coefficients permits the writing of additional simple equations to solve unusual cam problems, as it will be shown by a few examples.

Until this year we used "unity" tables for symmetrical diagrams or for the case when $p = 1$ or when the time for acceleration is equal to the time for deceleration.

Each table has 120 divisions, so that each division, as a step in the table, represents 1/120 of the working period of the cam. For each division, the table shows the displacement for the case when stroke $S = 1$.

To prepare the table for an actual cam, it is necessary to multiply the table displacement by the stroke. That work takes about two to three hours with a desk calculator plus the time for checking.

To cut a master cam, the shop divides the working period into 120 parts (or 60, 40, 30, etc., for smaller cams) and follows the prepared table.

Recently we started to receive orders for cams for which we could not or would not use "symmetrical" diagrams. This created the necessity for unity tables for a certain value of b (usually 0.25) and for different values of p.

At the request of Mr. Reader, who has to handle many unusual requirements for cams, modifications were worked out which require only six unity tables for practically any cam which can use a certain ratio b.

Actually only two forms are used for acceleration and deceleration: one is a modified trapezoid diagram with two quadrants of the sine curve, and the other has only one quadrant of the sine curve, *Fig.* 1.

When b is selected, the diagrams acquire certain shapes and properties; some of these properties are affected by the selection of p. Parameter b is selected arbitrarily, and p can be selected to establish either the relation between maximum acceleration and maximum deceleration or to reach the maximum velocity at a certain moment.

To cut a cam, it is necessary to have a table of displacements. The production of this table is the final aim of a designer. The problem then was to create unity tables to be used for any cam.

It was decided to make unity tables separately for the acceleration and the deceleration periods of all three types of diagrams. Normally we use 120 divisions in a table for the whole stroke. The new tables were made for 60 divisions in each one, so that one division represents 1/60 of the angle on which the cam rotates during the acceleration or the deceleration period. For making the final displacement table, only a calculator is required.

Acceleration diagrams for three types of cams are detailed in *Fig.* 9.

Conclusions: As the examples in *Fig.* 10 show, modified trapezoid diagrams permit the solving of problems quickly. The reasons are:

1. The diagrams, *Fig.* 9, retain the same general shape; hence, acceleration and velocity can be determined easily and used for writing additional equations.

2. In diagram I, the velocity coefficient is constant and independent of b or p.

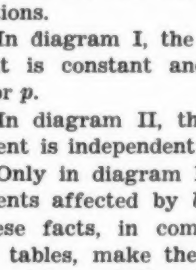
3. In diagram II, the velocity coefficient is independent of p.

4. Only in diagram III are all coefficients affected by b and by p.

These facts, in combination with unity tables, make the method flexible, quick, and therefore practical.

This method was developed under conditions usual for builders of special machines and for shops providing cams for many customers.

Calculating Dynamic Characteristics of Mechanisms



By Bayard E. Quinn
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Purdue University
Lafayette, Ind.

DESIGN of some devices must be based upon their dynamic characteristics. A camera shutter mechanism must expose the film for the proper length of time. A circuit breaker must interrupt the current within a specified time, and when the breaker is reclosed the ve-

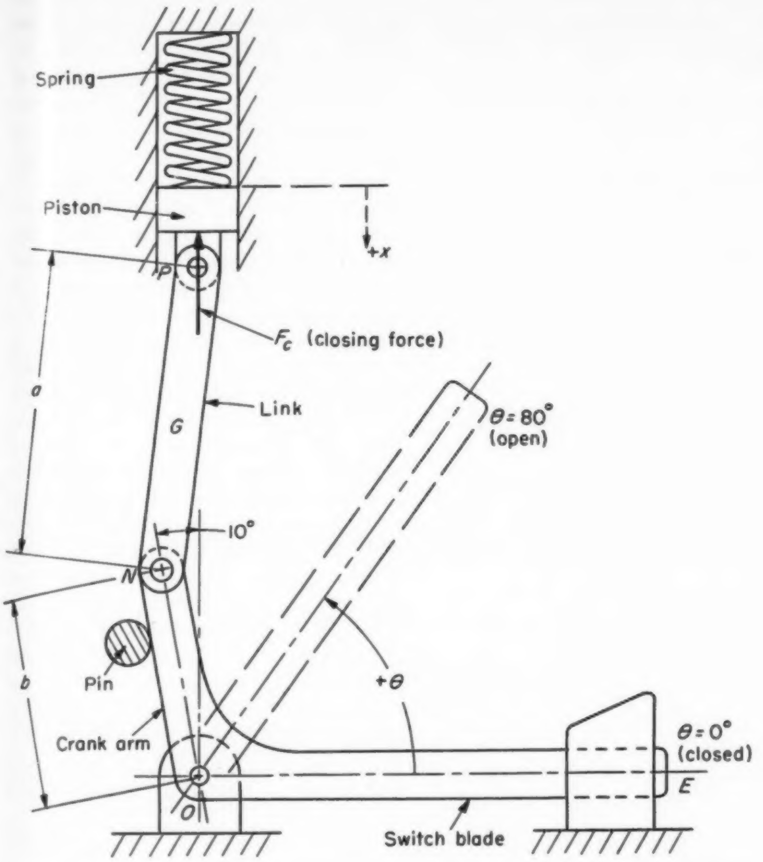


Fig. 1—Left—Switch mechanism for which dynamic analysis is made. Circuit is interrupted when switch blade rotates 15 degrees from closed position

Fig. 2—Below—Spring force versus piston displacement for spring used in switch mechanism of *Fig.* 1

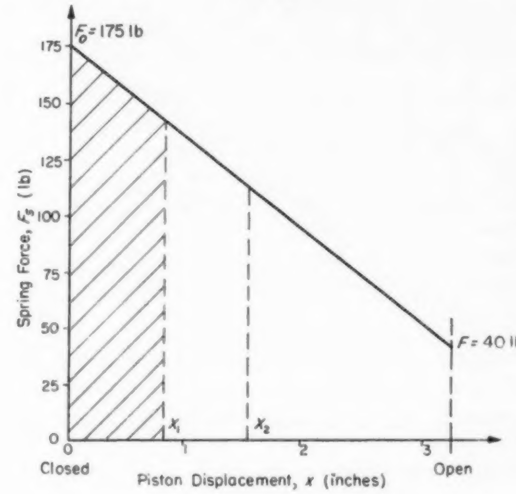


Fig. 3—Percentage of total kinetic energy in each switch part versus angular rotation of crank arm

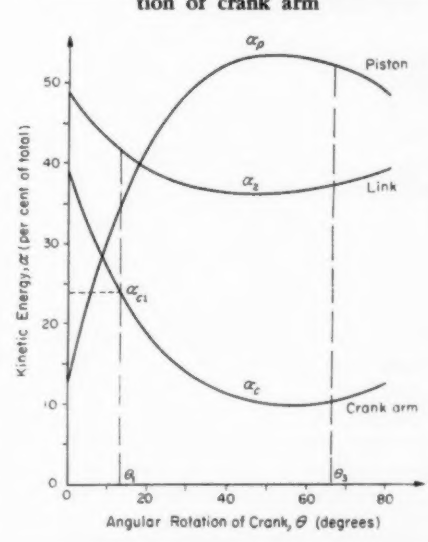
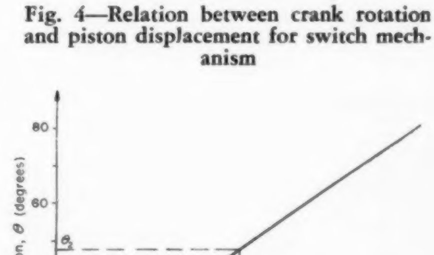


Fig. 4—Relation between crank rotation and piston displacement for switch mechanism



locity of the contacts must be high enough to prevent serious arcing as they come together. This paper presents a relatively simple procedure* that may be of assistance to the designer of such devices by enabling him to determine:

1. The dynamic characteristics that will result when a known force is applied to a mechanism.
2. The forces that must be applied to a mechanism to produce a desired dynamic characteristic.

The designer can therefore determine the dynamic behavior of the mechanism before it is constructed and can modify its proportions to obtain the desired characteristics. Procedure is based upon the theorem:

Percentage of the total kinetic energy which the link of a mechanism contains will remain the same, in any given position, regardless of the speed.

This theorem applies to mechanisms in which there is no change in the mass or moment of inertia with respect to speed, and in which a linear relationship exists among the velocities of the various links for any given position. (A more detailed discussion of these fundamental considerations is given in the cited paper.)

*B. E. Quinn—"Energy Method for Determining Dynamic Characteristics of Mechanisms," *Journal of Applied Mechanics*, Sept. 1949, Vol. 16, No. 3, Page 283.

In applying this theorem it is convenient to assign an arbitrary velocity to a convenient point in the mechanism and to compute the kinetic energy contained in each link for a given position of the mechanism. The total kinetic energy in the mechanism can then be obtained, and the percentage in each link can be computed. If these computations are repeated for several successive positions of the mechanism, a set of curves can be plotted in which the percentage of the total kinetic energy of the mechanism contained in each link can be shown as a function of displacement. By using this set of curves the dynamic characteristics can be investigated.

Determination of Dynamic Characteristics: In *Fig.* 1 is shown the schematic diagram of a switch mechanism. The actuating spring presses against a piston which is connected by a link to a crank arm. The switch blade is rigidly connected to the crank arm but is isolated electrically from it. The crank arm and the switch blade can therefore be considered mechanically as a single link. When the pin is withdrawn (by a mechanism not shown) the spring causes the blade to open to the position indicated by the dotted lines. It is required to determine the velocity of the blade when the circuit is

interrupted, if a spring having the characteristic shown in *Fig.* 2 is used in the mechanism. The following information is also needed:

Part	Weight (lb)	Moment of Inertia (lb inch sec²)
Piston	5	
Link*	4	$I_g = 0.020$
Crank arm†	6	$I_o = 0.020$

*$NP = a = 4.5$ inches, and the center of gravity, G, of the link is midway between N and P.
†$ON = b = 2.5$ inches, and $OE = 6$ inches.

Because it is necessary to consider the angular displacement of the switch blade and the linear displacement of the piston, a co-ordinate system is imposed on the mechanism as shown. For the closed position both θ and x are zero. Since positive blade rotation is counterclockwise, it follows that positive displacement of the piston is downward as shown.

First step is to determine the distribution of the kinetic energy for several different configurations of the mechanism. The kinetic energy of each link is indicated by letter T. A subscript letter identifies the part in question and a subscript numeral indicates the position. Thus T_{p1} represents the kinetic energy in piston p for position x_1.

These values are computed as follows:

$$T_p = \frac{1}{2}\frac{W_a}{g}(V_p)^2 \quad (1)$$

$$T_l = \frac{1}{2}\frac{W_b}{g}(V_g)^2 + \frac{1}{2}I_g\left(\frac{V_{np}}{a}\right)^2 \quad (2)$$

$$T_c = \frac{1}{2}I_o\left(\frac{V_n}{b}\right)^2 \quad (3)$$

A velocity of 10 inches per second is arbitrarily selected for point N and the other velocities are determined by graphical construction. (Since the distribution of the kinetic energy is independent of the speed, any value of V_n could be used and the same result would be obtained.) Total kinetic energy in the mechanism is then the sum of the energy contained in each link. When this is determined the percentage of the total kinetic energy in each link can be computed.

Suitable notation is needed in subsequent calculations to express the percentage of the total kinetic energy contained in a particular link for a particular position. Letter α will denote this percentage, with a subscript letter to represent the link in question and a subscript numeral to represent the position of the mechanism. Thus α_{p1} represents the percentage of the total kinetic energy of the mechanism in piston p when the mechanism is in position 1 (either x_1 or θ_1).

Results of these calculations are shown in *Fig.* 3, with the energy distribution as a function of crank rotation, θ. This could also have been plotted as a function of x. From the graphical construction used to determine the necessary velocities it is also possible to plot a curve of crank rotation, θ, versus piston displacement x, shown in *Fig.* 4. For 80 degrees of crank rotation a piston travel of approximately 3.2 inches will result.

It is now possible to determine the angular velocity characteristic of the blade when opening under the influence of the spring. For a selected value of θ_1 the corresponding value of x_1 is obtained from *Fig.* 4. In *Fig.* 2 the area under the curve from 0 to x_1 represents the work U_1 done by the spring on the mechanism as the piston moves from $x = 0$ to $x = x_1$. For this mechanism it is assumed that the energy dissipated by friction forces is negligible. Since the mechanism operates in a horizontal plane there is no change in the potential energy of the links since their centers of gravity are neither raised nor lowered. It can therefore be assumed that all the work done by the spring acting through the distance x_1 appears as kinetic energy in the various links of the mechanism for the configuration defined by x_1. For these conditions in which α_{c1} is determined

$$T_{c1} = \alpha_{c1}\, U_1 \quad (4)$$

from *Fig.* 3 as indicated. After T_{c1} is known the angular velocity of crank arm, c, for the position θ_1 is computed from Equation 3. One point is thus obtained for the curve shown in *Fig.* 5.

The analysis is continued by selecting a convenient value for θ_2 and then determining the corresponding value of x_2 from *Fig.* 4. The total amount of work done by the spring from $x = 0$ to $x = x_2$ is then the corresponding area under the curve in *Fig.* 2. (To U_1 could be added the area from $x = x_1$ to $x = x_2$ to obtain the same value.) This quantity

Fig. 5—Angular velocity of crank arm as a function of its angular rotation

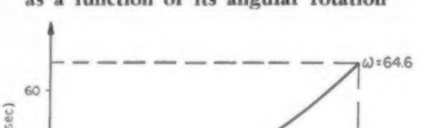


Fig. 6—Angular rotation of crank arm as a function of time

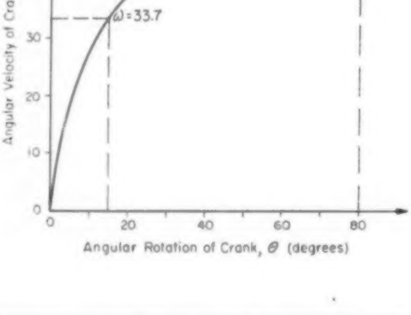


Fig. 7—Required relation between angular velocity and angular position of switch arm during closing

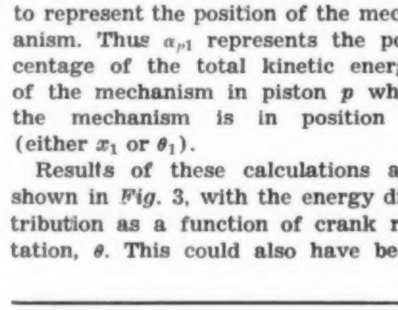
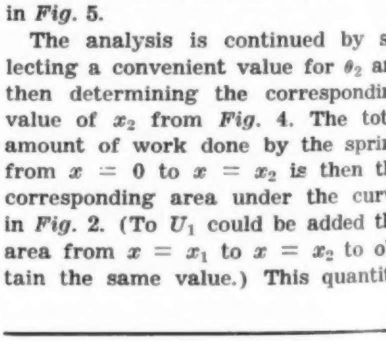


Fig. 8—Total kinetic energy in switch mechanism during closing



is represented as U_2 and

$$T_{c2} = \alpha_{c2} U_2 \quad \text{(5)}$$

The calculations are repeated as previously described and the angular velocity of the blade for position θ_2 is determined. The resulting curve is shown in *Fig.* 5 on which the angular velocity at $\theta = 15$ degrees is indicated.

Other dynamic characteristics can be determined from the curve after it has been constructed. The crank angle versus time curve is determined by using the relationship

$$\Delta t = \frac{\Delta\theta}{\omega} \text{ or}$$

$$t = \int \frac{d\theta}{\omega} \quad \text{(6)}$$

for which the necessary values are obtained from *Fig.* 5 to make a numerical integration. This curve is shown in *Fig.* 6.

It can be seen that in mechanisms where the energy input is known and where the distribution of this energy can be determined it is possible to compute the dynamic characteristics with relative ease.

Determination of Applied Forces: The opening of the switch is accomplished by using the spring. In order to close the switch, however, it is necessary to apply a force to the under side of the piston. This force F_c, shown in *Fig.* 1, acts only during the closing stroke. The closing motion of the blade is fixed by the specification that the blade should have constant angular acceleration until $\theta = 45$ degrees, after which it

should have constant angular deceleration. The closing time is specified as 0.07-sec. It is required to determine the magnitude of the force necessary to produce this motion and to compress the spring for the next motion cycle. From the specifications the curve of angular velocity versus angular displacement (ω-θ) for the closing stroke is plotted, *Fig.* 7.

For any position, such as θ_3, of the blade during closing it is thus possible to determine the angular velocity. From Equation 3 the kinetic energy of the blade is computed for this position. From *Fig.* 3 the percentage of the total kinetic energy in the blade for the position θ_3 is determined. With these values it

SAMPLE CALCULATIONS

Following are the calculations for determining one point on each of the computed curves in this article.

Fig. 3—Distribution of kinetic energy. A velocity polygon is drawn for an assumed mechanism configuration, *Fig.* 1, of $\theta = 30$ degrees, with an assumed value of 10 inches per second for V_n. From this polygon the following velocities are obtained: $V_g = 8.78$ inches per sec, $V_{np} = 8.20$ inches per sec, and $V_p = 9.36$ inches per sec. Then, from Equations 1, 2 and 3,

$$T_p = \frac{1}{2}\left(\frac{W_a}{g}\right)(V_p)^2 = \frac{1}{2}\left(\frac{5}{386}\right)(9.36)^2 = 0.567 \text{ in-lb}$$

$$T_l = \frac{1}{2}\left(\frac{W_b}{g}\right)(V_g)^2 + \frac{1}{2}(I_g)\left(\frac{V_{np}}{a}\right)^2$$

$$= \frac{1}{2}\left(\frac{4}{386}\right)(8.78)^2 + \frac{1}{2}(0.020)\left(\frac{8.20}{4.5}\right)^2 = 0.432 \text{ in-lb}$$

$$T_c = \frac{1}{2}(I_o)\left(\frac{V_n}{b}\right)^2 = \frac{1}{2}(0.020)\left(\frac{10}{2.5}\right)^2 = 0.160 \text{ in-lb}$$

and

$$T_{total} = T_p + T_l + T_c = 0.567 + 0.432 + 0.160 = 1.159 \text{ in-lb}$$

then

$$\alpha_p = 100\left(\frac{T_p}{T}\right) = 100\left(\frac{0.567}{1.159}\right) = 48.9 \text{ per cent}$$

$$\alpha_l = 100\left(\frac{T_l}{T}\right) = 100\left(\frac{0.432}{1.159}\right) = 37.3 \text{ per cent}$$

$$\alpha_c = 100\left(\frac{T_c}{T}\right) = 100\left(\frac{0.160}{1.159}\right) = 13.8 \text{ per cent}$$

which are plotted in *Fig.* 3.

Fig. 4—Crank rotation versus piston displacement. Curve is plotted from the mechanism configurations used to obtain the velocities needed for *Fig.* 3.

Fig. 5—Angular velocity. The area U under the curve in *Fig.* 2 from $x = 0$ to $x = 0.823$-inch (corresponding to $\theta = 30$ degrees) is computed to be 129.6 in-lb. Thus, as in Equation 4,

$$T_c = \alpha_c U = 0.138\ (129.6) = 17.9 \text{ in-lb}$$

and, since $T = \frac{1}{2} I\omega^2$,

$$\omega = \sqrt{\frac{2T_c}{I_o}} = \frac{2\ (17.9)}{0.020} = 42.3 \text{ rad per sec}$$

This is the value of ω at $\theta = 30$ degrees, plotted in *Fig.* 5.

Fig. 6—Time relationship. The time is computed for 5-degree intervals of rotation. For example, the increment of time Δt required for the blade to rotate from $\theta = 15$ degrees to $\theta = 20$ degrees is given, as in Equation 6, by

$$\Delta t_4 = \frac{\Delta\theta}{\omega} = \frac{0.0872}{35.6} = 0.00245\text{-sec}$$

and the total time required to reach $\theta = 20$ degrees is

$$t = \Delta t_1 + \Delta t_2 + \Delta t_3 + \Delta t_4$$

$$t = 0.00830 + 0.00364 + 0.00280 + 0.00245$$

$$t = 0.01719\text{-sec}$$

Fig. 7—Closing velocity. This curve is plotted from information given in the first paragraph on *Determination of Applied Forces.*

Fig. 8—Kinetic energy in closing. At the position $\theta = 60$ degrees ($x = 2.248$ inches) the value of ω is 30.2 radians per second, from *Fig.* 7. Then

$$T_c = \frac{1}{2} I_o \omega^2 = \frac{1}{2}(0.020)(30.2)^2 = 9.09 \text{ in-lb}$$

Total kinetic energy in the mechanism is then

$$T = \frac{T_c}{\alpha_c}(100) = \frac{9.09}{10.0}(100) = 90.9 \text{ in-lb}$$

Fig. 9—Closing force. At $x = 2.60$ inches the value of Δt for an increment $\Delta x = 0.2$-inch is -20 lb, from *Fig.* 8. Then, from Equation 7,

$$F = \frac{\Delta T}{\Delta x} = \frac{-20}{0.2} = -100 \text{ lb}$$

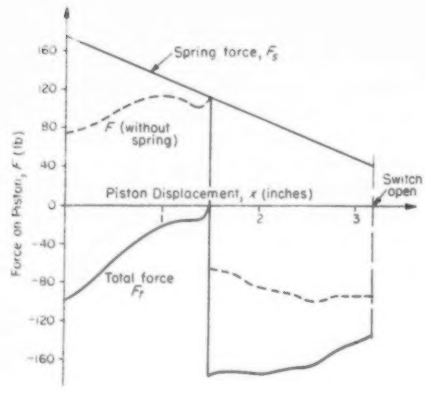


Fig. 9—Force required on piston to close the switch

is then possible to determine the total amount of kinetic energy, T, in the mechanism. The total kinetic energy, T, is then plotted as a function of the piston displacement x, using *Fig.* 4. This relationship is shown in *Fig.* 8.

With friction neglected as before (and the effect of the spring omitted for the present) the kinetic energy T must be supplied by the closing force F. The work done by F from the extreme open position to any intermediate position x_3 must then be equal to T_3. If the piston undergoes a slight additional displacement Δx, then

$$\Delta T = F(\Delta x) \qquad (7)$$

from which

$$F = \frac{\Delta T}{\Delta x} \qquad (8)$$

It is thus evident that the slope of the $(T\text{-}x)$, *Fig.* 8, curve represents the force F at that position. The slope of the curve is determined at several selected values of x and the $(F\text{-}x)$ curve constructed, *Fig.* 9. From the co-ordinate system previously established it can be seen that an upward force exists at the beginning of the closing stroke, since F is negative. A reversal of direction occurs later as the mechanism is brought to rest.

Spring force F_s also is plotted in *Fig.* 9. It is now possible to determine the total force F_t required to close the mechanism with the desired velocity characteristic, and also to compress the spring:

$$F_t = F - F_s \qquad (9)$$

When the switch starts to close, F_t is equal to the sum of the magnitudes of F and F_s and acts upward on the piston, as indicated by the negative sign. Near the middle of the closing stroke the value of F becomes positive and therefore the magnitude of F_t decreases to almost zero. When the switch is almost closed the increase in F_s causes F_t to take on larger negative values, as shown in *Fig.* 9. The unusual shape of the $(F_t\text{-}x)$ curve indicates possible difficulty in producing exactly the desired type of motion.

Conclusions: If the distribution of the kinetic energy in a mechanism is known, and if the amount of work that goes into kinetic energy can be determined, the dynamic characteristics can be computed. One of the difficulties lies in determining accurately the work that goes into kinetic energy.

Energy losses of various types occur in many mechanisms and are not always easy to evaluate. The method does, however, offer advantages over some of the more classical methods of analysis that become complicated for relatively simple mechanisms.

ACKNOWLEDGEMENTS. The author wishes to thank Mr. Irving Kobsa, a former student, for his contribution to the theory outlined in *Determination of Applied Forces,* and Mr. James C. Wolford for making the calculations and constructing the curves for this paper.

Predicting Performance of High-Speed Mechanisms

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MANY publications on dynamic analysis of mechanisms have dealt with the problem of deriving velocities, accelerations, and forces from the prescribed motion of one of the links. Typical of these problems is the classical engine mechanism analysis in which the angular velocity of the crank is assumed constant and prescribed, and the dynamic analysis of the mechanism is then derived.

In machine design the engineer often encounters the converse problem. He has to predict the dynamic behavior of a mechanism without being able to assume the motion of any link as given. Instead he knows what forces are exerted on one or more links of the mechanism or, possibly, he has to derive the motion of a linkage where no external forces are applied. Examples of such problems include the dynamic behavior of an engine during starting or during deceleration, the action of a machine-gun mechanism which is actuated by the initial impulse given to one of the links, and the operation of a mechanism actuated by pneumatic or hydraulic cylinders. In these and numerous other instances dynamic performance has to be predicted without prior knowledge of the motion of any of the links. A recent paper by Quinn[1] gives an important and useful tool, based on an energy approach, for the solution of such problems. The author has found this and similar methods most useful. However, in certain situations advantages can be gained from methods derived directly from the laws of motion rather than from the energy balance. This is particularly true when frictional forces are significant. The techniques discussed in this paper are based on an approach in which the equations of motion of a mechanism are derived from the free-body diagram of each link. These equations are combined into a single differential equation which is solvable by quadratures; the displacements, forces, velocities, and accelerations are then derived as functions of time.

Principles underlying this method are not new. Techniques presented here use basic, familiar design tools, such as the free-body diagram and the velocity and acceleration vector diagrams. It is hoped, therefore, that they may be of assistance in machine design applications.

To illustrate the essentials of the method, consider the mechanism shown in *Fig.* 1. Both links move in translation. Link 1 is acted upon by a helical spring which is under ini-

[1]References are tabulated at end of article.

tial compression. The problem is to predict the variation of the significant displacements, velocities, accelerations, and forces in the mechanism. No attempt is made to complete the problem by specifying a method of decelerating the links since this is not essential to this illustration.

Since the cam curve is given in analytical form as

$$y = D\,(1 - \cos bx) \quad \text{(1)}$$

relations for the velocities, accelerations and the camming angle θ may be obtained readily as follows:

$$\frac{dy}{dt} = \frac{dx}{dt}\, b\, D \sin bx \quad \text{(2)}$$

$$\frac{d^2y}{dt^2} = \left(\frac{dx}{dt}\right)^2 b^2\, D \cos bx + \frac{d^2x}{dt^2}\, b\, D \sin bx \quad \text{(3)}$$

$$\tan\theta = \frac{dy}{dx} = b\, D \sin bx \quad \text{(4)}$$

The free-body diagrams of the two links then yield the equations

$$K - kx - N \sin\theta = MA \quad \text{(5)}$$

$$N \cos\theta = ma \quad \text{(6)}$$

Combining these equations

$$A + \frac{mb^3\, D^2 \cos bx \sin bx}{M + mb^2\, D^2 \sin^2 bx}\, V^2 = \frac{K - kx}{M + mb^2\, D^2 \sin^2 bx} \quad \text{(7)}$$

where $A = V\,(dV/dx)$. It should be noted that this equation might also have been derived by establishing an energy balance, leading to an equation in terms of V^2 and differentiating with respect to x.

Equation 7 is a first-order differential equation of the type

$$V\frac{dV}{dx} + m(x)\, V^2 = n(x) \quad \text{(8)}$$

The solution, with V expressed in terms of x, may be obtained by standard[2] methods as

$$V^2 = 2\, e^{-r} \int_0^x n(x) e^r\, dx \quad \text{(9)}$$

where

$$r = 2 \int_0^x m(x)\, d_x$$

If the initial velocity is not zero, as in this example, Equation 9 contains a term corresponding to the initial velocity, which may also be derived as shown in the reference.[2]

Equation 9 represents a series of elementary mathematical operations which may easily be performed by the use of a slide rule or a desk calculator. In particular any of the standard methods of tabular or graphical integration[3] may be used to evaluate Equation 9 if, as is frequently the case, the functions $m(x)$ and $n(x)$ are available in tabular or graphical form.

From the velocity-displacement variation, represented by Equation 9, the time-displacement function may be derived from

$$t = \int_0^x \frac{dx}{V} \quad \text{(10)}$$

In practice this is equivalent to taking the reciprocals of the ordinates of the velocity-displacement diagram and performing a further integration leading to the time-displacement diagram. Equations 9, 7, and 5 then serve to give the time-variation of the velocities and accelerations of the two links and that of the contact force N.

In reviewing the foregoing procedure, the following significant steps, which are characteristic for the general method of solution here presented, may be identified:

Step 1: From free-body diagrams derive the equations of motion for each link (in terms of as yet unknown forces and accelerations).

Step 2: Combine these equations by using the geometric relations characterizing the mechanism. This leads to a first-order differential equation for the velocity of one of the links in terms of its displacement.

Step 3: Solve this equation by quadrature to obtain the velocity-displacement relation explicitly.

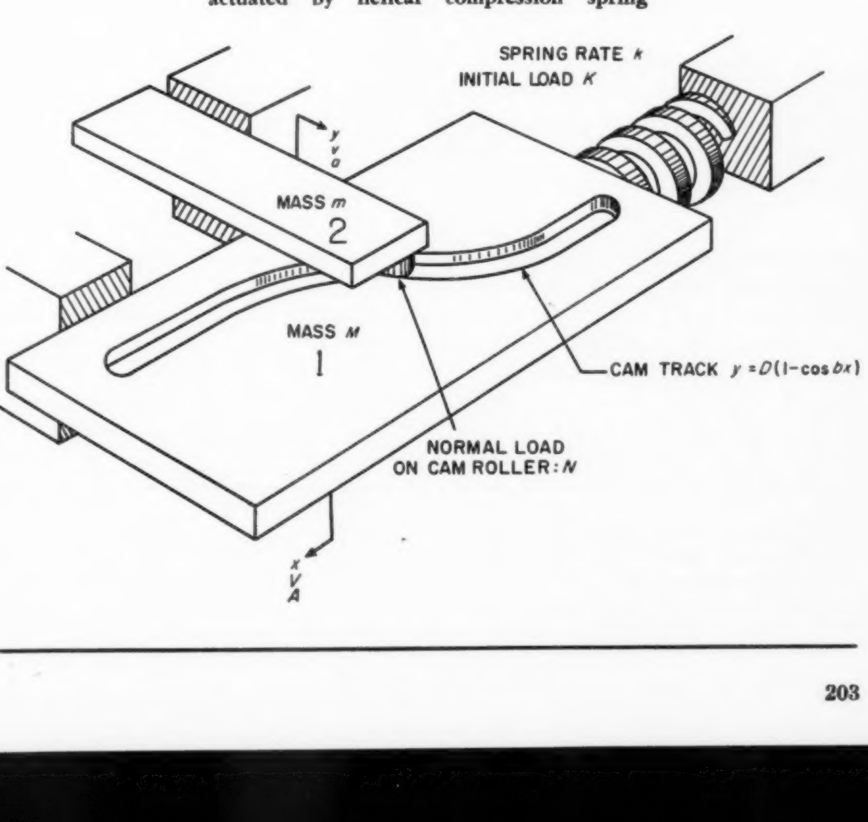
Step 4: By one inversion and further integration, obtain the displacement-time relation. Velocities, accelerations, and forces may then be obtained by using this result along with the relations derived in Steps 1 and 2.

These steps will be discussed further:

Step 1: One of the advantages of this method lies in the fact that frictional effects can be taken into account. Some of the forces included in the equations of motion will normally be due to friction. In analyzing a large number of mechanisms the author has found that the use of Coulomb friction, i.e., of a constant coefficient of friction, is quite adequate for many mechanism design problems. In addition, the method can include any forces acting on the links of the mechanism which are expressible as functions of displacement, or are proportional to the square of velocity, or to acceleration, i.e., such forces as spring forces, gas compression or expansion forces and friction forces.

Although the choice of a suitable coefficient of friction may be difficult for a completely new mechanism configuration, an appropriate selection can often be made on the basis of comparison of past theoretical and experimental results. In other cases, several plausible values of this co-

Fig. 1—Mechanism with two sliding masses actuated by helical compression spring



efficient may be used in order to "bracket" the probable solution.

Forces whose variations are known only as a function of time cannot be included without modification. In a number of instances where such forces were present it has been possible to approximate them as functions of displacement, then carry through the normal procedure and, if necessary, improve the first approximation and repeat the procedure.

It should be noted that the force relations included in *Step* 1 need not be known in analytical form. Because a tabular or machine computer solution is normally used in conjunction with this procedure, forces which are given only in graphical, tabular, or other nonanalytical form can be included.

Step 2: The principal difficulty which may arise in this step lies in the nature of the geometrical relations. Unlike the example cited, the relations among displacements, velocities, and accelerations in even a simple linkage mechanism are not normally obtainable in analytical form. At the same time it must be remembered that only the ratios of those quantities are needed. Generally speaking, *Step* 2 will lead to equations of the type

$$V_{QO} = f(x)\ V_{PO} \qquad (11)$$

$$A_{QO} = g(x)\ V_{PO}^2 + f(x)\ A_{PO} \qquad (12)$$

where P is a point on the reference link, Q is a point on some other link, and $f(x)$ and $g(x)$ $[=d/dx\ f(x)]$ are functions of the displacement, x, of the reference link.

The function $f(x)$ in Equation 11 is normally obtainable by using one of the standard methods, such as the velocity vector diagram procedure, for obtaining the ratios of velocities between points of a mechanism. Any convenient reference velocity may be used since only the ratios of velocities are involved. It may be noted that the velocity vector diagram leading to $f(x)$ of Equation 11 is, at the same time, also the acceleration vector diagram for the mechanism taken at zero velocity; this is shown by Equation 12 according to which $f(x)$ is obtained by considering the ratio of A_{QO} to A_{PO}, with V_{PO} equal to zero. Experience confirms that when the velocity is assumed zero, and all normal accelerations therefore disappear, a conventional acceleration vector diagram for a mechanism becomes geometrically similar to the velocity vector diagram.

Preparation of an acceleration vector diagram, with V_{PO} as reference velocity, provides the function $g(x)$ of Equation 12.

Step 3: Because this step involves an integration of functions given either in analytical or graphical form, many methods of procedure are available. In the author's experience a simple desk calculator is sufficient to solve many common mechanism problems speedily. The form of Equation 8 makes it suitable for digital or analog machine computation also. If the parameters of the problem are

Fig. 2—Sample problem illustrating dynamics of linkage mechanism

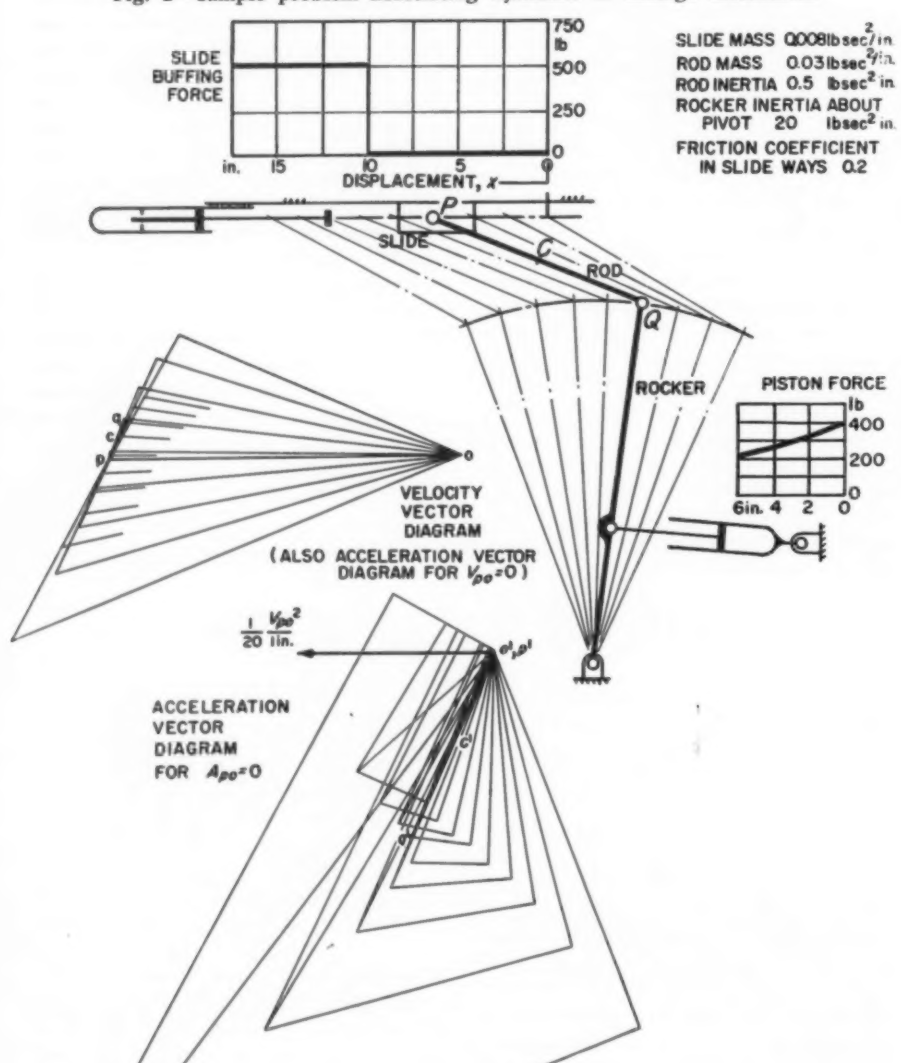
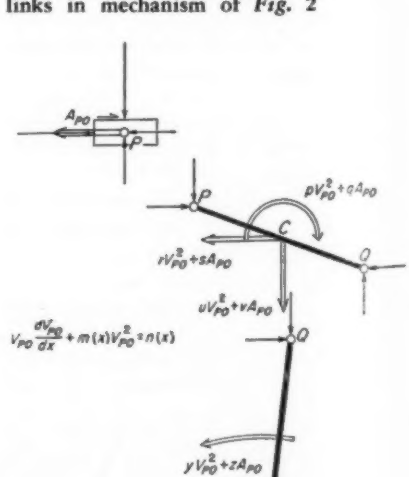


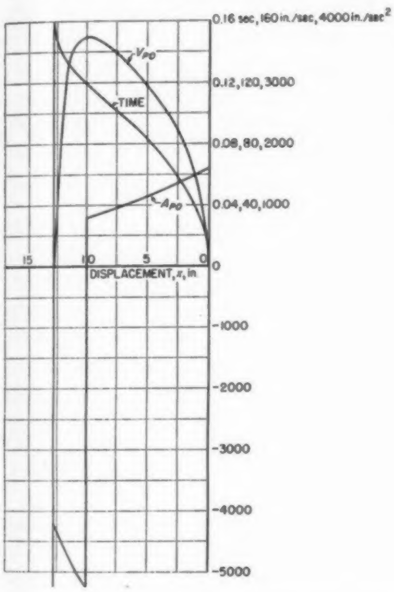
Fig. 3—Free-body diagrams of links in mechanism of *Fig.* 2



to be varied over a wide range, which frequently happens when an optimum design is to be derived, the analog machine is normally more convenient. Although its accuracy is generally lower than that of a digital machine, large numbers of pertinent solutions can be obtained quickly and in readily analyzable form.

In the analog machine Equation 8 may be reconverted to a "time basis", i.e., expressed in a form in which time is the independent variable. If only a single set of parameters is of interest and if high accuracy is required a digital machine is useful. Its operation would follow the identical steps otherwise used in desk calculator methods. After some experience in punching cards and setting up the problem, operators can achieve considerable savings in computing time. Any of the common methods for integrating graphically by the use of Simpson's multipliers, or other procedures, are applicable to the integration represented by Equation 9.

Fig. 4—Velocity, acceleration and time curves for the mechanism of *Fig. 2*



Step 4: The principal difficulty which may be encountered here occurs when the velocity-displacement function derived in *Step* 3 has one or more zeros. Because the initial velocity in many problems is zero, this is a common occurrence. Several methods are available for obtaining a solution in the region at and near zero-velocity points.

In certain problems it is possible to change variables to avoid the difficulty. For example, in a four-bar linkage in which dead-center positions occur for the driver as well as for the follower, Equation 8 may be written in terms of the driver velocity and displacement when it is near and at alignment with the connecting-rod, and conversely for the follower. In other problems, for certain cam

paths, it is possible to write Equation 8 in terms of a suitable parametric variable so as to avoid the points of zero velocity.

A method which is normally successful and simple relies on the fact that the displacement at and near a particular position of a mechanism, as a function of time, may be expressed in terms of the velocity, acceleration and, if necessary, higher derivatives, at that position. Thus, if the reference position is designated by the subscript $_o$,

$$x = x_o + V_o\,(t - t_o) + \frac{1}{2} A_o\,(t - t_o)^2 + \ldots\ldots\ldots \quad (13)$$

A solution at and near a point of zero velocity may therefore be obtained approximately as

$$x = x_o + \frac{1}{2} A_o\,(t - t_o)^2 \;\ldots\ldots \quad (14)$$

Since Equation 8 yields the value of A_o for $V_o = 0$ without difficulty, the time-displacement function may thus be obtained directly and "pieced together" with the solution for the remainder of the problem. Provided the region in which Equation 14 is used is kept small, this method is sufficiently accurate for most purposes.

Table 1—Tabular Solution of Sample Problem Shown in Fig. 2

Quantities and Method of Determination	Units	Numerical Values								
a. Position of Mechanism (see layout of Fig. 2)		0	1	2	3	4	5	6	7	8
b. Slide Displacement, x (position of Point P, Fig. 2)	in.	0	2.2	4.3	6.4	8.5	10.4	12.2	14.0	15.5
c. Velocity Ratio, V_{QO}/V_{PO} (velocity vector diagram, Fig. 2)	1	0.88	0.91	0.94	0.96	1.00	1.04	1.10	1.20	1.38
d. Acceleration Ratio at Zero Velocity, $A_{QO}/A_{PO}\|_{V=0}$ (same as c.)	1	0.88	0.91	0.94	0.96	1.00	1.04	1.10	1.20	1.38
e. Square of Velocity Ratio, V_{QO}^2/V_{PO}^2 (from c.)	1	0.78	0.83	0.88	0.92	1.00	1.08	1.21	1.44	1.90
f. Normal Acceleration Ratio, $V_{QO}^2/(V_{PO}^2 \times$ length of rocker) (from e. and Fig. 2)	1/in.	0.039	0.042	0.044	0.046	0.050	0.054	0.060	0.072	0.095
g. Velocity Ratio, V_{QP}/V_{PO} (velocity vector diagram, Fig. 2)	1	0.40	0.32	0.22	0.12	0.02	0.09	0.21	0.36	0.58
h. Acceleration Ratio at Zero Velocity, $A_{QP}/A_{PO}\|_{V=0}$ (same as g.)	1	0.40	0.32	0.22	0.12	0.02	0.09	0.21	0.36	0.58
i. Square of Velocity Ratio, V_{QP}^2/V_{PO}^2 (from h.)	1	0.16	0.10	0.05	0.01	0.00	0.01	0.04	0.13	0.34
j. Normal Acceleration Ratio, $V_{QP}^2/(V_{PO}^2 \times$ length of rod) (from i. and Fig. 2)	1/in.	0.013	0.008	0.004	0.001	0.000	0.001	0.003	0.010	0.027
Note: Items f. and j. are used to construct the acceleration vector diagram shown in Fig. 2.										
k. Angular Acceleration Coefficient y of Fig. 3 (from acceleration vector diagram, Fig. 2)	1/in.²	0.00088	0.00071	0.00067	0.00069	0.00092	0.00144	0.00215	0.00377	0.00790
l. Angular Acceleration Coefficient z of Fig. 3 (from velocity vector diagram, Fig. 2)	1/in.	0.044	0.046	0.047	0.048	0.050	0.052	0.055	0.060	0.069
m. Angular Acceleration Coefficient p of Fig. 3 (from acceleration vector diagram, Fig. 2)	1/in.²	0.0033	0.0035	0.0037	0.0038	0.0043	0.0049	0.0059	0.0090	0.0145
n. Angular Acceleration Coefficient q of Fig. 3 (from velocity vector diagram, Fig. 2)	1/in.	-0.032	-0.025	-0.017	-0.009	-0.002	0.007	0.017	0.029	0.047
o. Linear Acceleration Coefficient r of Fig. 3 (from acceleration vector diagram, Fig. 2)	1/in.	0.016	0.013	0.011	0.010	0.010	0.012	0.016	0.028	0.056
p. Linear Acceleration Coefficient s of Fig. 3 (from velocity vector diagram, Fig. 2)	1	0.90	0.93	0.95	0.98	1.00	1.02	1.04	1.08	1.14
q. Linear Acceleration Coefficient u of Fig. 3 (from acceleration vector diagram, Fig. 2)	1/in.	0.014	0.018	0.020	0.021	0.025	0.027	0.032	0.044	0.073
r. Linear Acceleration Coefficient v of Fig. 3 (from velocity vector diagram, Fig. 2)	1	-0.18	-0.14	-0.10	-0.06	-0.01	0.04	0.09	0.15	0.25
Note: The equations of motion for each of the links shown in Fig. 3 may be combined in any one of several sequences to give the resulting equation, in terms of V_{PO}, shown in Fig. 3. The mechanism dimensions needed for the force equations of each link are taken from the layout of Fig. 2.										
s. Coefficient $m(x)$ in Differential Equation of Fig. 3	1/in.	0.015	0.012	0.011	0.011	0.014	0.021	0.030	0.039	0.092
t. Coefficient $n(x)$ in Differential Equation of Fig. 3	in./sec²	1600	1455	1430	1205	1065	-4740	-4350	-3830	-3140
u. Velocity V_{PO} (from Equation 9 of text)	in./sec	0	81	110	130	143	148	68	-	-
v. Time Elapsed from Start of Motion (from Equation 10 of text)	sec	0	0.052	0.076	0.094	0.109	0.122	0.142	-	-
w. Acceleration A_{PO} (from Equation of Fig. 3 with $A_{PO} = V_{PO}\,dV_{PO}/dx$)	in./sec²	1600	1380	1300	1020	880	-5200	-4490	-	-

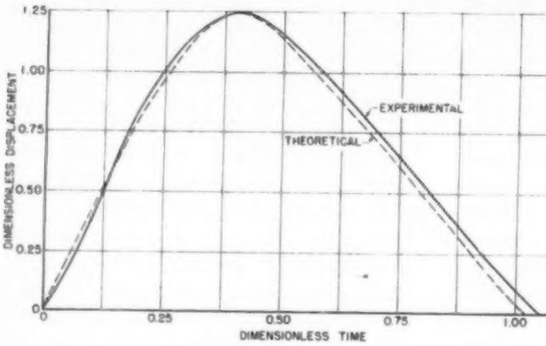


Fig. 5 — Predicted time-displacement diagram for a high-speed mechanism compared with test result

Figs. 2, 3, and 4 and *Table* 1 show the sequence of operations for an illustrative sample problem. *Fig.* 2 gives the displacement relations and, by way of the velocity and acceleration vector diagrams, the coefficients required for the establishment and combination of the equations of motion of the free-body diagrams of *Fig.* 3. It should be noted, particularly, that each of the linear and angular accelerations shown in *Fig.* 3 is expressed as the sum of two terms, the first a function of the square of the velocity of the reference point *P*, the second of its acceleration. *Fig.* 4 shows the resulting variation of velocity, acceleration and time and indicates that, for the conditions postulated, the mechanism comes to rest after about 13 inches of motion of the slide.

In *Fig.* 5 the time-displacement relation predicted by this method for a high-speed mechanism is compared to a test record taken with a drum camera. The maximum displacement and cycle time in the actual mechanism were on the order of a few inches and about 50 milliseconds; it will be noted that agreement between the experimental and theoretical results is fairly close.

Summary: The method presented provides a useful tool in the solution of dynamic mechanism problems in which no prior knowledge of the motion of any of the links exists. It is capable of taking into account friction forces and other forces which are functions of displacement, or are proportional to the square of velocity or to acceleration. The method provides equations for the force relations for all links; it also yields values of acceleration at points of zero velocity, so that the motion at and near such points can be derived in a simple manner.

ACKNOWLEDGEMENT: The author would like to express his gratitude to his co-workers, particularly Dr. K. E. Bisshopp and Messrs. D. K. Skoog, M. G. Kinnavy and N. W. Carey, for many valuable contributions to the techniques presented herein.

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Analysis of Mechanisms with High-Speed Photography

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IT IS evident that we at Kodak might be expected to think of using high-speed photography when some others might not; but actually there are many times when the cobblers' children are not well shod, and we sometimes fail to use the photographic approach when it would be useful.

There are about 3,000 people whose job it is to design, construct, and maintain the buildings and equipment at Kodak Park, the largest of the Kodak plants. About 500 of these are in the Engineering division with a group of 60 involved in the design of the automatic machinery I want to describe so that you can better understand the use we make of high-speed photography.

This machinery in general is used to perform operations, such as cutting and packaging on sensitized film or paper; in the manufacture of mechanical items, such as spools and magazines used in conjunction with sensitized goods; or to perform operations on processed film, such as the mounting of Kodachrome transparencies. Most of this machinery cannot be purchased as standard equipment because of the limited market there would be for it. It is advantageous to design and build this machinery at Kodak Park to meet the unusual requirements relating to (1) the care with which sensitized products must be handled, (2) the ability to operate safely and to maintain machinery in nearly total darkness, and (3) the frequent incorporation of optical devices for latent image printing or for restricted safelighting.

These machines cover the full range from simple bench fixtures to complex, fully automatic high-speed machines. They may be mechanically, hydraulically, pneumatically, or electrically actuated and electrically or electronically controlled. Because of the high speeds and the invisible flow of such media as oil, air, and electrons, visualization becomes necessary to a complete understanding of the operation of modern machinery. Most of these machines you cannot turn over slowly to see what happens, and if you did the machine and the product would not behave the same as at normal speed.

With many machines in industry, the problem is to make the machine do what it is supposed to do; but with us it is more often to make the product do what it is supposed to do. There is no ready way to calculate how paper will fold or feed or how sheets will fall. We must design from experience and some simple tests and make the necessary adjustments or alterations after the machine is built. It is in this phase of a project that high-speed movies are most helpful.

High-speed photography is a tool, an instrument relatively easy to use that will change the time scale by several hundred to one and which allows one to see milliseconds of time as readily as one can see thousandths

of an inch with micrometers. The actual measurement has no effect on the device or product being studied except for the effects of light.

In the oral presentation of the paper, a sequence of high-speed movies was shown which were typical of the many that we have taken in the last few years. In this version, selected single frames have been enlarged to illustrate some of the uses that we have made of high-speed photography.

Perforator: We are interested in what happens throughout the speed gamut of a high-speed machine. A 16-mm perforator was operated experimentally at twice normal speed. It was noted from the high-speed movies that the shuttle which advances the film oscillated about its normal motion with an overshoot at the end of the advance stroke. This overtravel introduced misalignment of the pilots engaging the film, as shown in *Fig.* 1, and damage to the film resulted. This oscillation about the normal advance stroke was studied through a speed range by high-speed photography, by strain gage measurements, and by calculation. It became evident that the oscillation occurred at the natural frequency of the driven mass of the shuttle and that the amplitude of the oscillation varied as the cube of the speed. We concluded that the rate of change of acceleration was the cause of the oscillation and therefore designed a cycloidal cam to replace the constant-acceleration cam. These cam calculations were carried out on our payroll department computing machines so that we could obtain the high accuracy necessary to minimize third derivative values. It turned out to be practical to recut the existing cam for a slightly larger cam follower since the difference between the two cam paths did not exceed 0.020-inch at any point.

A marked improvement can be seen with the redesigned cam, *Fig.* 2. There was a smoother deceleration without appreciable oscillation or overshoot. This picture was taken with the perforator operating faster than in the preceding sequence. It is interesting to note that it would be difficult to be certain from the strain gage records that the perforator was performing satisfactorily because large deflections were still present, but at times in the cycle when accuracy was not important. The accurate positioning of the film as the pilots enter is what counts.

Cam Follower: The cam roller shown in *Fig.* 3 is experiencing far from rolling contact and might better be described as a slider which continuously presents a new surface. Lubrication and light loads enable this arrangement to give satisfactory service.

Paper Stacker: The fingers of a high-speed sensitized paper stacker were studied in operation. The sheets are brought forward by grippers, are released, and are then dropped down into the stack by the stacking fingers. It was noted that when the sheet was forward in the gripper, a deflection, as in *Fig.* 4, of the edge of the sheet occurred at the stacking finger. This deflection caused a photographic effect even though the physical damage to the

Fig. 1—Perforator pilot pins engaging misaligned perforated holes

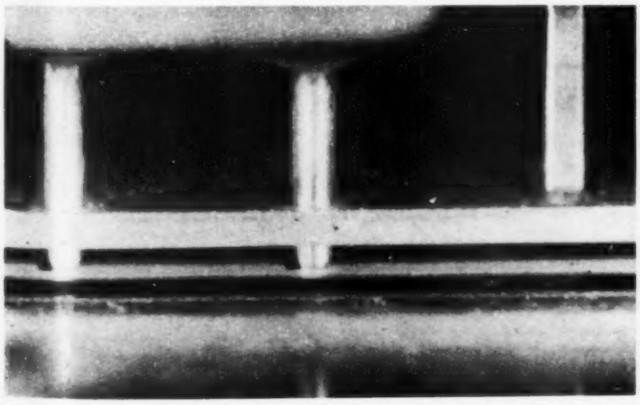


Fig. 2—Perforator pilot pins engaging perforated holes using redesigned shuttle cam

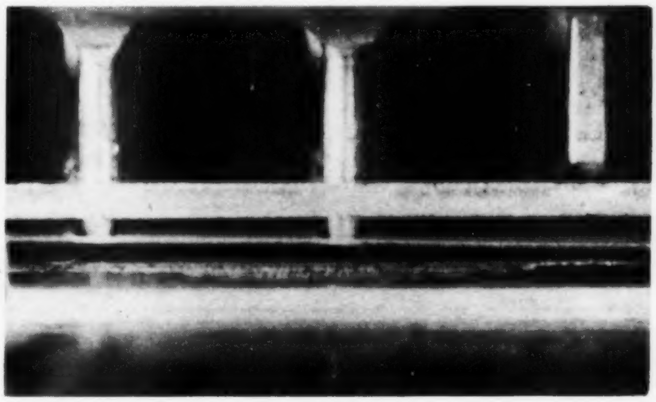


Fig. 3—Cam follower roll rotation

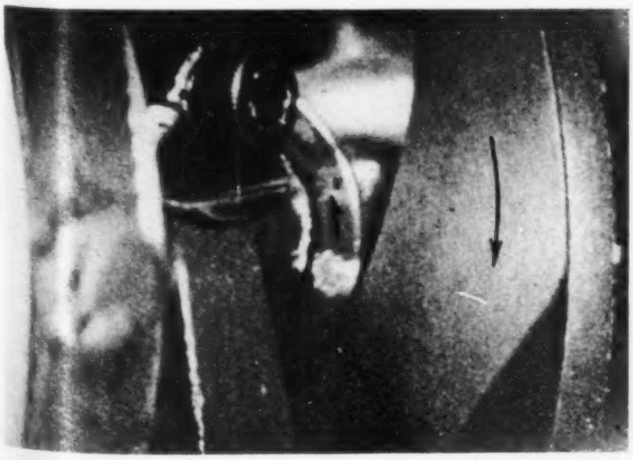
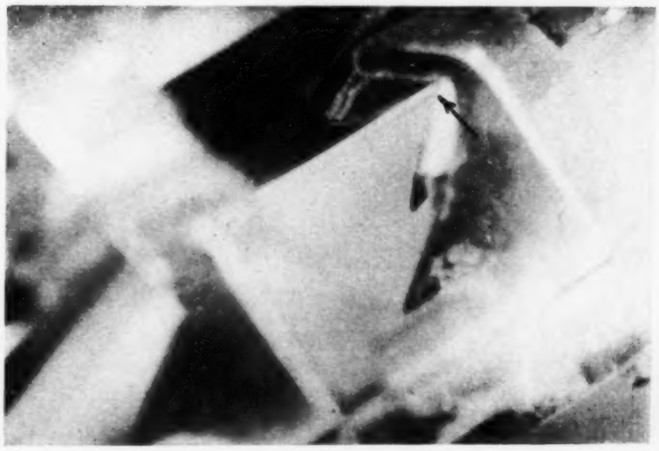


Fig. 4—Sheet of paper hitting stacking finger



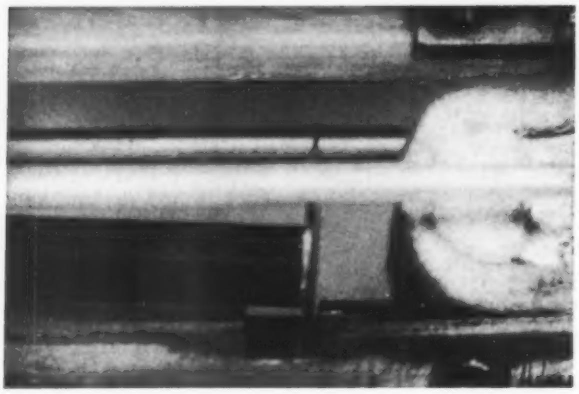


Fig. 5 — Film spool bouncing off bumper

sheet was not visible when the sheets were later inspected. A sheet which was held farther back in the gripper did not get this damage.

Spool Feeder: After fabrication and painting, roll-film spools are inspected for accuracy by rolling them through accurately spaced tracks. Spools having bent flanges or which are out of tolerance stick in these tracks and are removed as rejects. In feeding the spools to the track gaging, they must be in single file

Fig. 6—Sequence showing roller bouncing across film pack

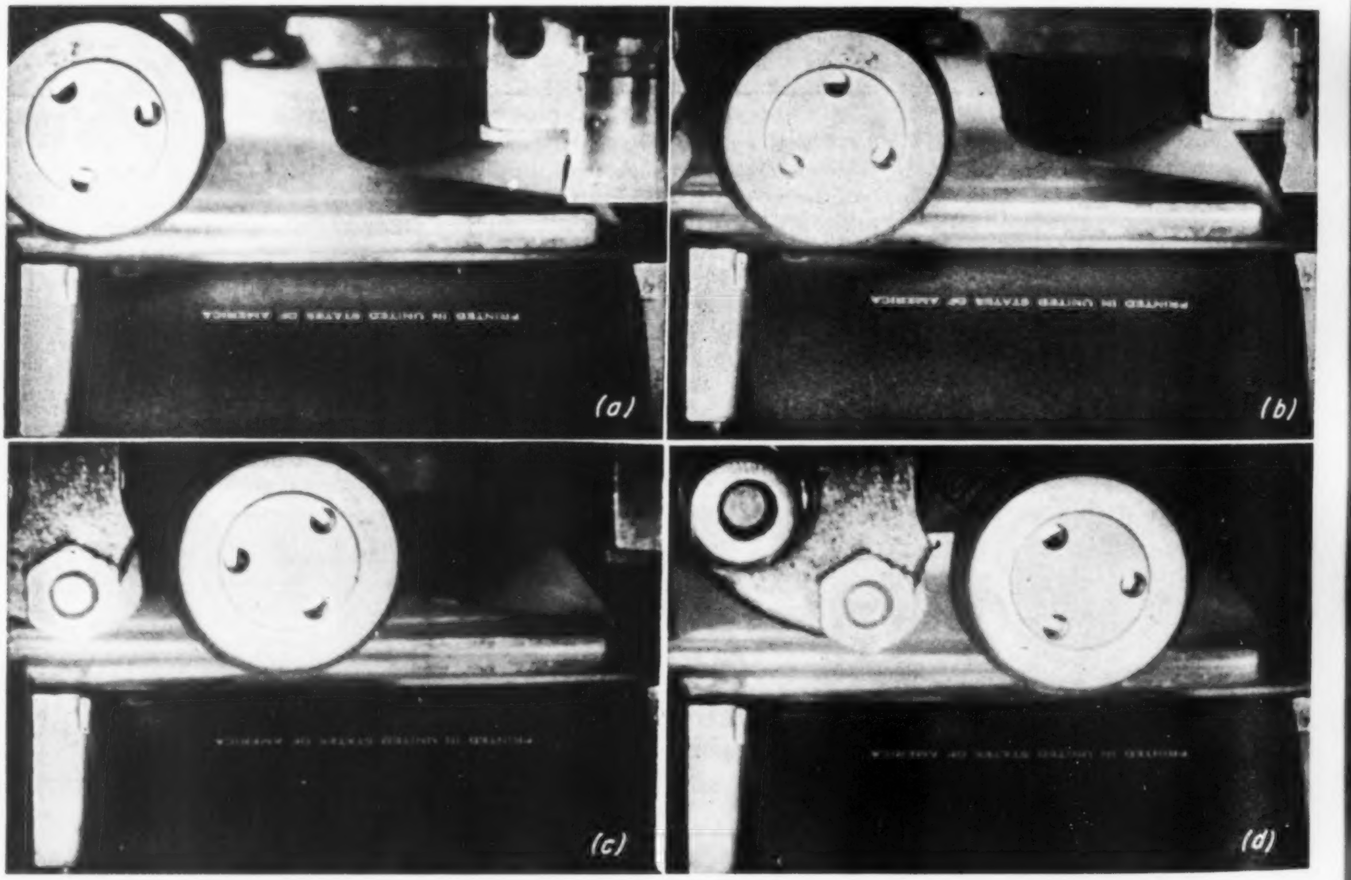


Fig. 7—Sheet metal blank falling out of inclined punch press

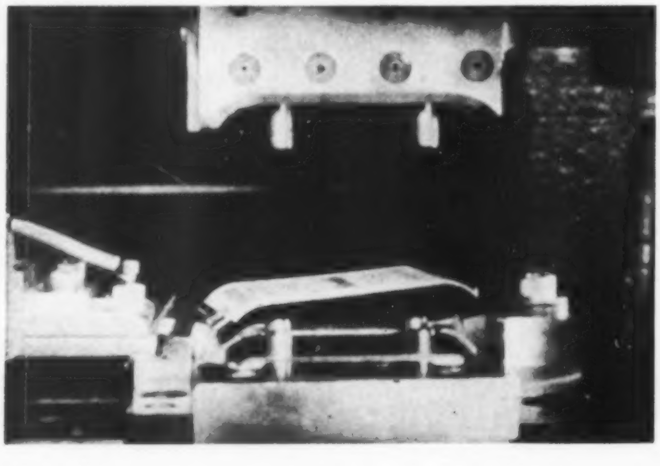
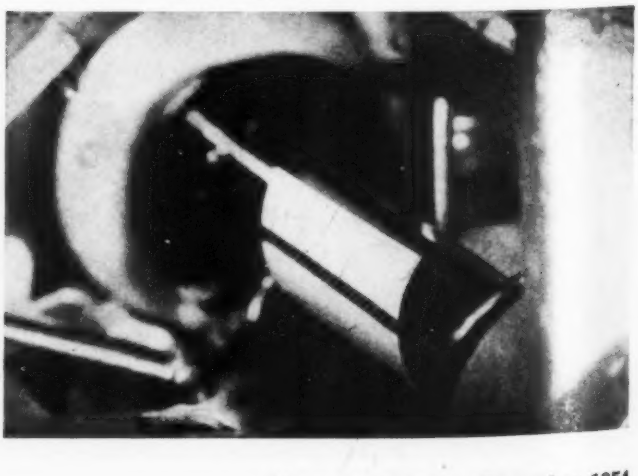


Fig. 8—Paper tab pulling out of slot of film spool



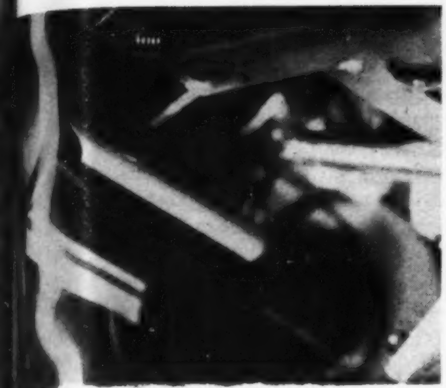


Fig. 9—Oscillographic trace on high speed movie film

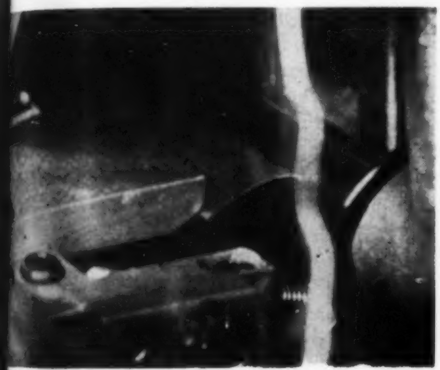


Fig. 10—Paper threading using abutment on transfer slide

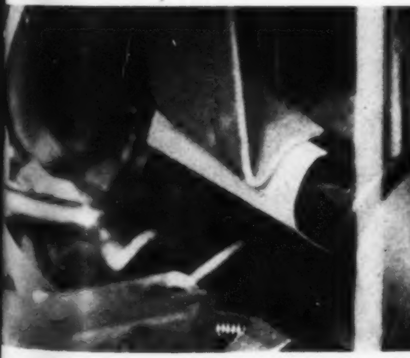


Fig. 11—Makeshift bracket which indicated solution to paper threading problem

and spaced from each other. The feeding device, *Fig.* 5, was studied with high-speed movies to determine the best way to arrest their lengthwise motion and start them rolling sidewise.

Film Pack: A study was made of the moistening and application of a gummed paper tape which serves to attach the film to the paper tab in the manufacturing of film packs. Excess water on the tape is hazardous to the film and proper control was arrived at by means of this study.

The gummed tape is then rolled down by a rubber roller. On the initial design, the roller bounced as it came onto the tape, as shown in *Fig.* 6. This condition was corrected after it was seen in the high-speed movies. A second stroke which the roller makes was done without bouncing even in the original.

Inclined Punch Press: High-speed movies were taken to determine how the blanks drop out of an inclined punch press. *Fig.* 7 is a view looking down through the die. The stripper pins raise the blank out of the nest, and it then slides down into a stacker. Occasional failure of the blanks to fall properly lead to feed jams and damage to the die. An understanding of this problem gained through high-speed movies indicated corrective changes.

Paper Threading: High - speed movies were very useful in a step-by-step analysis of an experimental spooling operation on 120 size film. It appeared from visual observation that the paper tab either was not entering the slot in the spool or that the spool was starting to turn before the paper had fully entered the slot. The high-speed pictures showed that the larger diameter of the tube of this particular size of spool permitted the paper tab to bend and pull out of the slot instead of winding, as shown in *Fig.* 8.

The next phase of this experiment involved the use of an auxiliary feature of the Kodak high-speed camera which permits showing an oscillographic trace directly on the high-speed film. The oscilloscope is used with no vertical sweep so that the horizontal displacement of the spot traces a wavy line just like an ordinary strip chart recorder. In this experiment an ordinary phonograph pickup needle was allowed to ride on the paper so that the oscillographic trace would show as a wavy line when the paper was in motion, as shown in *Fig.* 9. This was done to determine whether the movement of the paper was properly synchronized with the rotation of the spool. Forward motion of the paper was indicated when the oscillograph line started to wiggle.

An abutment shown on the spool transfer slide in *Fig.* 10 was next tried for the purpose of bending over the short protruding tab of paper as the spool started to turn. It did not have the desired effect because the tab was caused to wave back and forth and it pulled out even more readily than before. This approach might have been successful if the transfer slide could have been permitted to stay over longer but the timing was very close.

A make-shift bracket, *Fig.* 11, was then tried which bent the short tab over at the same time that the spool started to pull the paper forward, and then raised for the subsequent winding. This experiment indicated a practical solution to a rather baffling problem.

Summary: High-speed movies can be very useful in the development of automatic machinery. The cost of high-speed movies can frequently be saved in the engineering time required to find the trouble by other means. Continued savings may result from improved machine operation reducing down time, maintenance, and product waste. And finally, high-speed movies give you that comfortable feeling of knowing what is going on.

Straight-Line Mechanisms

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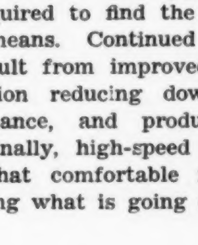
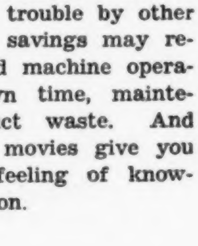




A STRAIGHT-LINE mechanism is a linkage device used to guide a given point in an approximate straight line. Several such mechanisms use five or more links to produce exact straight-line motion of a given point. A four-link (or four-bar) mechanism using finite links

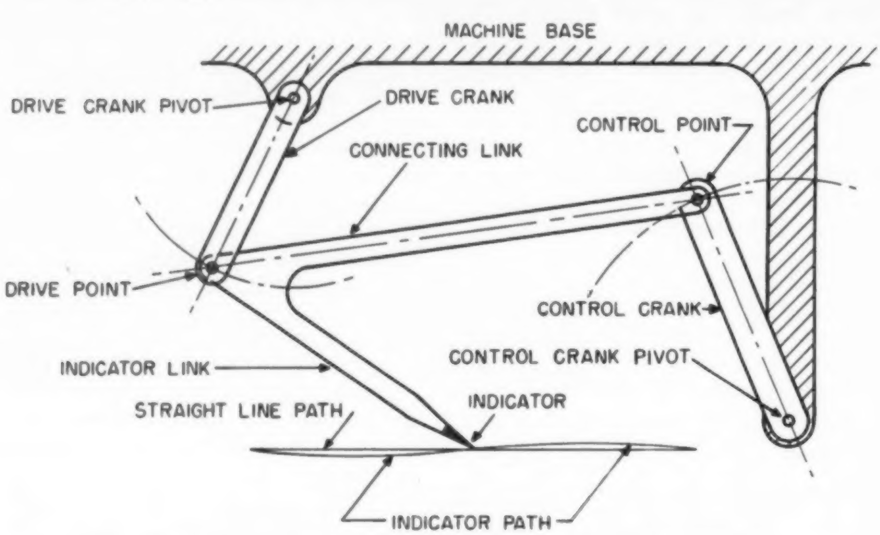


Fig. 1—Terminology of a four-bar straight-line linkage mechanism

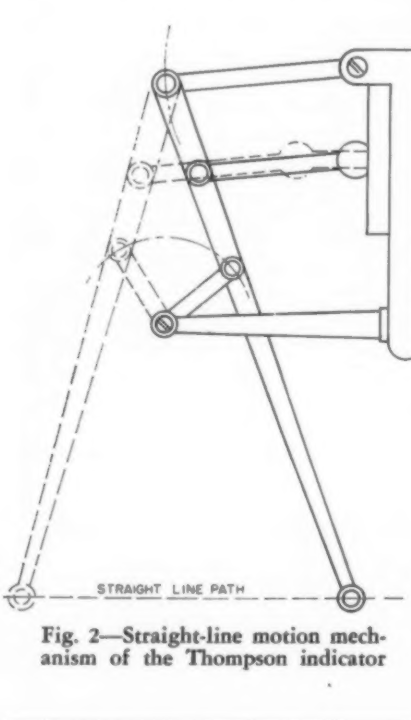


Fig. 2—Straight-line motion mechanism of the Thompson indicator

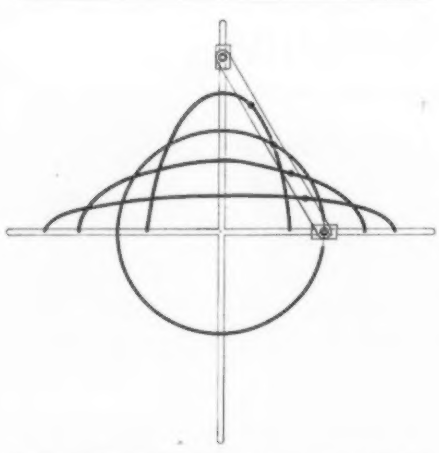


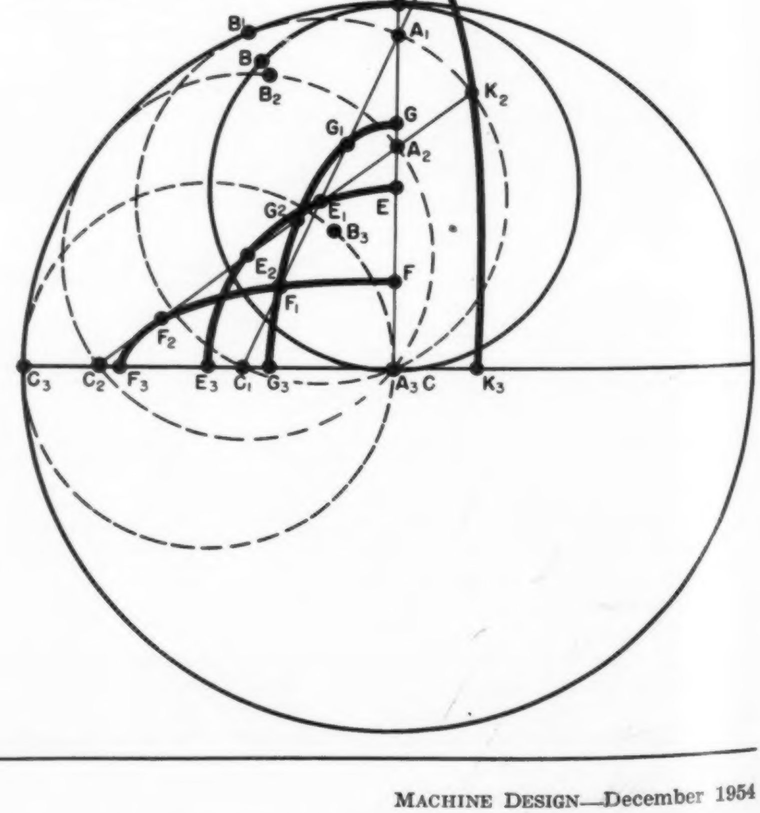
Fig. 3—Elliptic trammel, on which the Thompson indicator mechanism is based

can only approximate a straight line. This discussion will deal only with these four-bar approximate straight-line mechanisms.

The four elements of a four-bar linkage, *Fig.* 1, as used here, are: (1) A link which will be caused to move so that one point thereon, called the *indicator,* travels along the desired path. This link is composed of two rigidly connected parts: (*a*) the connecting link, joining the drive point and the control point and (*b*) the indicator link, connecting the indicator to the drive point; (2) A *drive crank,* to which a turning torque is applied to move the mechanism and which is connected to the link at the drive point; (3) A *control crank,* which serves only to guide the link control point in the proper path; and (4) The *base* of the machine, to which the two cranks are pivotally attached. For identification purposes, *indicator path* will be used to describe the approximate straight-line path through which the indicator travels and *straight line* will mean the desired theoretical straight line. The *indicator path* and the *straight line* will coincide at three or four places.

Delco Radio division's interest in straight-line mechanisms centers mainly on their use for a radio station indicator. In this application, motion is amplified considerably between the tuner and the indicator to give a pleasing, expanded dial. The four-bar straight-line mechanism is ideal for this purpose, having low mass in the high-speed element, and amplifying motion with a minimum of frictional work at its pivoted joints. This contrasts markedly with a slider type mechanism, where the relatively bulky station indicator moves along a straight guide, producing friction

Fig. 4—Circles of Cardano. Anv point on the rim of the rolling wheel generates a straight line; other points on the wheel generate ellipses



and inertia at the machine element of greatest motion.

Thompson Indicator Mechanism: Probably the most widely used straight-line mechanism, and virtually the standard of the auto radio industry for indicating the tuned frequency, is a four-bar linkage based upon the Thompson indicator, *Fig.* 2. This and several other well known straight-line mechanisms, are based on the elliptic trammel, *Fig.* 3, a double-slide arrangement with a connecting link moving over the slides so that two points move in straight lines usually, though not necessarily, at right angles to each other. All points of the link generate ellipses of varying eccentricity. The midpoint of the link generates an ellipse of zero eccentricity, which is a circle.

To develop a straight-line linkage mechanism from the elliptic trammel, portions of two of the ellipses are approximated by circular arcs; links which will travel these circular arcs are used to drive the elliptic trammel crosshead in an approximate straight line. The Thompson indicator mechanism approximates one of the straight lines (or ellipse with zero minor axis) with the control crank, which is made as long as possible. Sometimes a slider replaces this control crank, being in effect an infinitely long control crank.

A similar geometric figure, the Circles of Cardano, *Fig.* 4, uses a wheel rolling inside a circular track of twice the radius of the wheel. All points on the rim of the wheel travel in straight lines passing through the center of the track, and all other points connected with the wheel trace ellipses. If this wheel is interchanged with the link of an elliptic trammel, the motion will be identical.

A series of equations has been developed to eliminate cut-and-try graphical solutions in the design of straight-line mechanisms of the Thompson indicator type, *Fig.* 5. Only half of the mechanism is shown in the picture as the other half adds nothing to the solution, being usually a mirror image. Accuracy of the straight-line approximation will diminish as the crank pivot is moved farther away from the indicator line (as G is increased) and also as the crank arc is made larger (as θ is increased). Since the degree of accuracy in approximating a straight line is affected by several parameters, no hard-and-fast rules can be established as to maximum usable eccentricity and crank angles.

Generalized Methods: Until recently, the designer had little recourse other than to search for published

A = TOTAL LENGTH OF POINTER = D + E + G.
C = 1/2 REQUIRED POINTER TRAVEL.
G = DISTANCE FROM POINTER PIVOT TO TIP.
E = LENGTH OF BELL CRANK ARM
D = DISTANCE BETWEEN CONTROL HOLES ON POINTER.
Θ = 1/2 ANGLE OF BELL CRANK

GIVEN C, G, Θ

$$E = \frac{C^2}{2G(1-\cos\Theta)+2C\sin C}$$

$$D = \frac{\sin\Theta(E^2+EG)}{C-E\sin\Theta}$$

GIVEN C, G, R

$$A = \sqrt{C^2+(G+R)^2}$$

$$S = \frac{D+E+R}{2} = \frac{A-G+R}{2}$$

$$D = \frac{AS}{A+R}$$

$$\tan\Theta = \frac{DC}{AR-DR-DG}$$

$$E = A - D - G$$

FOR CURVED POINTER TRAVEL GIVEN C, G, Θ, M

$$E = \frac{C^2-2GM-M^2}{2G(1-\cos\Theta)\pm 2M+2C\sin\Theta}$$

$$D = \frac{\sin\Theta(E^2+EG\pm EM)}{C-E\sin\Theta}$$

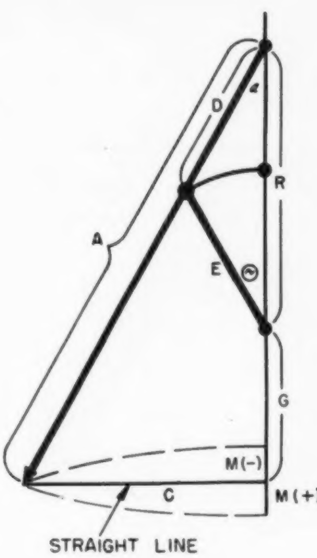


Fig. 5—Proportions of Thompson indicator straight-line mechanism

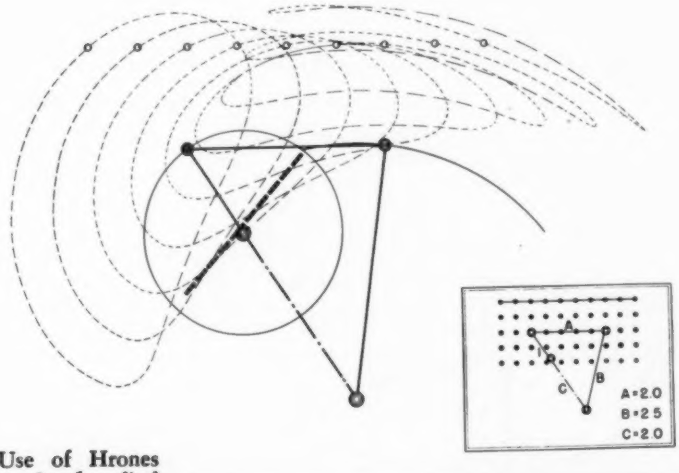


Fig. 6—Use of Hrones and Nelson chart[1] to find a straight-line mechanism. A point on link A lying between the third and fourth dots in the upper part of the diagram will describe an approximate straight line over the portion of its travel indicated by heavy broken line. Chart reproduced by permission of the publishers

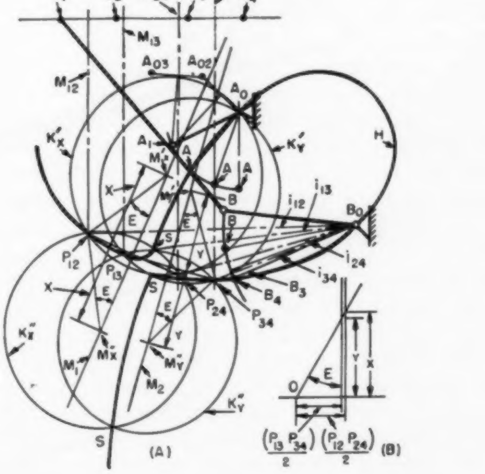


Fig. 7—Construction for deriving a mechanism with an indicator which will pass through four points on a straight line, C_1, C_2, C_3 and C_4. Pivot for control crank, B_o, must be on "curve of Burmester's centers," *H*

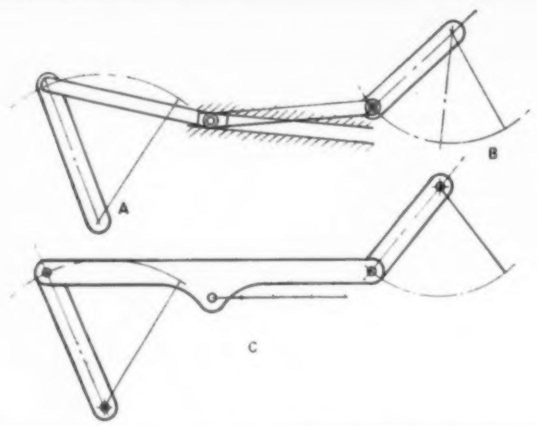
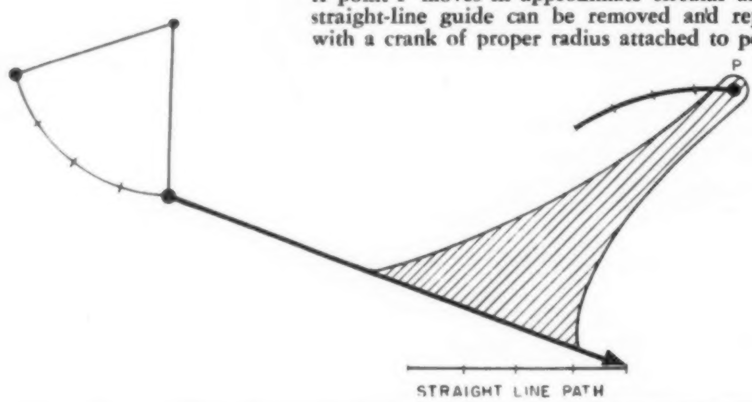


Fig. 8—Straight-line linkage based on two slider-crank mechanisms. Arc-match method is used to derive right-hand portion of linkage

Fig. 9—Connecting link of slider-crank mechanism. If point *P* moves in approximate circular arc, the straight-line guide can be removed and replaced with a crank of proper radius attached to point *P*



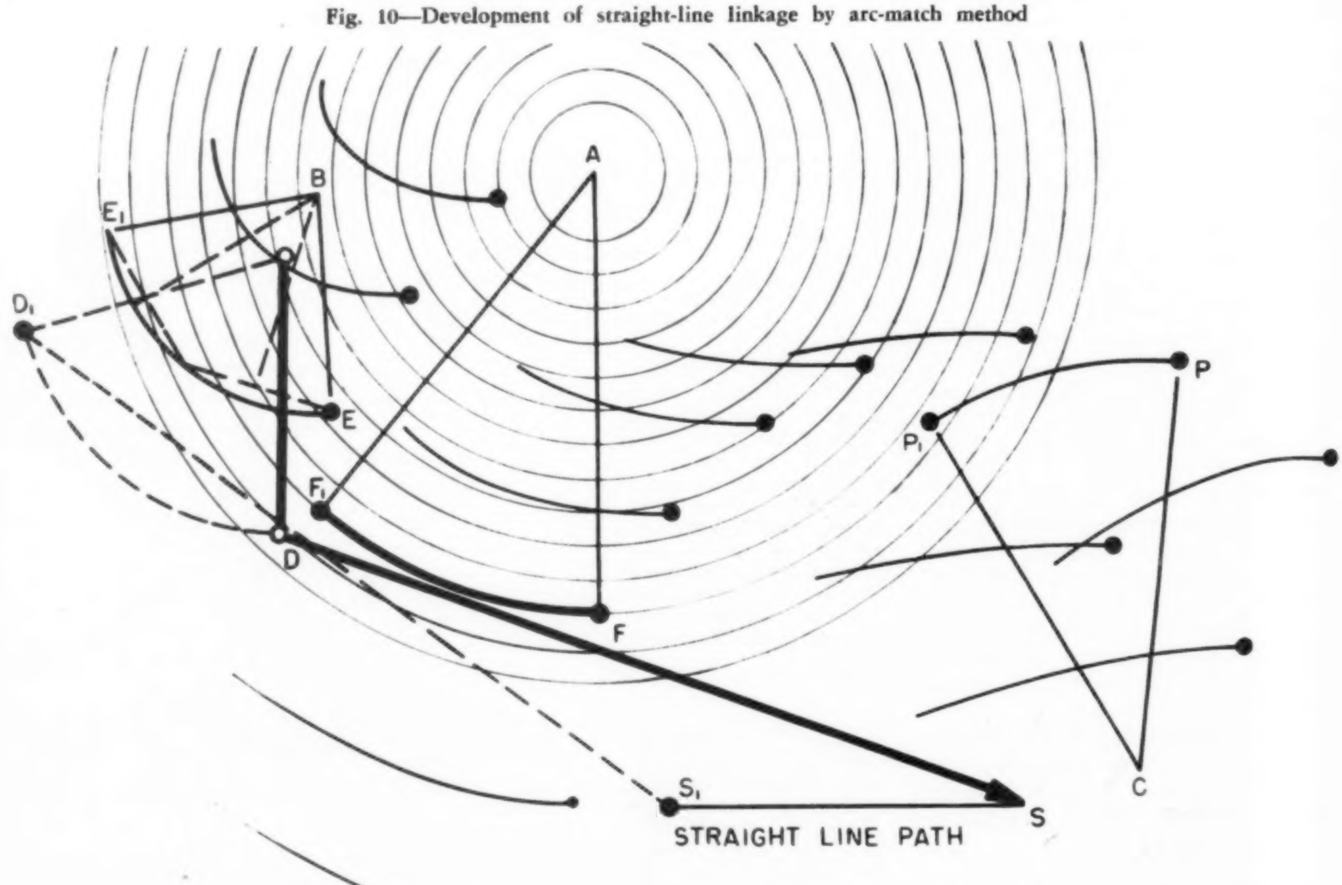
mechanisms which might be used. Little has been published about designing these mechanisms with other than the exact proportions specified by the inventors. Three generalized methods of linkage design will be briefly covered in this discussion.

Atlas Method: In 1950 Hrones and Nelson[1] published an ***Atlas*** of curves prepared to help the linkage designer. This book systematically catalogs the curves generated by points on a link driven by crank and rocker mechanisms, the drive crank having 360-degree rotation and the rocker (or control crank) having reciprocating motion such that it cannot pass through dead center and lock the mechanism. A typical page of this 730-page atlas is reproduced in *Fig.* 6. Five such pages are used for each linkage combination with 10-point paths plotted on each page. To use this book in the design of a straight-line mechanism, the designer searches for straight lines, or adjacent paths which curve in opposite directions, indicating an approximate straight line somewhere between the two.

Use of an atlas in designing straight-line mechanisms is limited

[1]References are tabulated at end of article

Fig. 10—Development of straight-line linkage by arc-match method



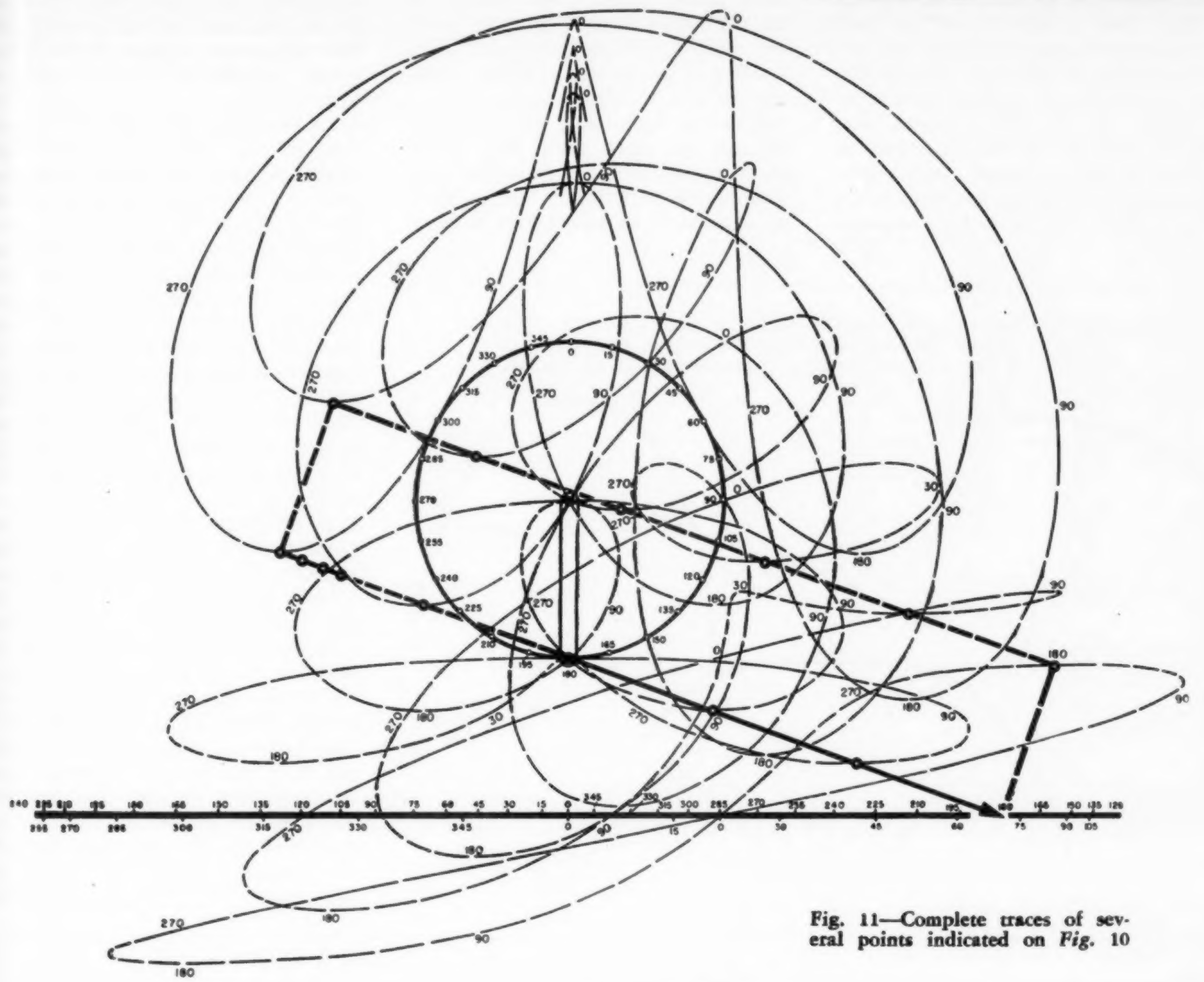


Fig. 11—Complete traces of several points indicated on *Fig.* 10

at present, since there are many published straight-line mechanisms, including the Thompson indicator, which have proportions outside the realm of work published to date.

Burmester Method: In 1953, Kraus and Rangasami[2] showed a graphical method of designing a four-bar straight-line mechanism, *Fig.* 7. Their method utilizes a theory of linkage design advanced by L. Burmester[3] in 1888. The illustration shows how four positions of the indicator, C_1, C_2, C_3, and C_4, and the corresponding four positions of a crank *B,* are used to develop a *curve of Burmester's centers, H.* Any point on this curve may be used as the pivot for a crank which will control the indicator. The indicator will coincide with the desired straight line at the *four* selected points.

Arc-match Method: A more generalized graphical approach to the design of a four-bar straight-line mechanism is the *arc-match* method. This is more or less a combination of the Atlas and Burmester methods. As in the Burmester method, the procedure starts with a specified drive-crank included angle, and a specified straight-line output. This constitutes the basis for designing a slider-crank mechanism, or harmonic transformer, presented at last year's conference by Nickson[4].

A slider crank to perform a specified function is shown in *Fig. 8a.* If another slider crank is added, as shown in *Fig. 8b,* the new crank will serve as a control crank for an exact straight-line mechanism if there is no relative angular motion between the two links or, in other words, if the indicator link and the connecting link can function as one solid link, *Fig. 8c.* The arc-match system is a graphical procedure for finding a second slider crank to combine with the first to produce an equivalent four-bar straight-line linkage.

A selected slider crank, with one additional point *P* rigidly connected to the link, is shown in *Fig.* 9. If the indicator is constrained to travel the selected straight line while the drive crank rotates, the point *P* will travel the arc shown. This arc will be called the *trace* of the point *P.* If this trace is a circular arc, a crank of proper length may be connected at this point to control the linkage so that the indicator travels in a straight line with the constraining slider removed. However, since no point on any slider-crank mechanism will travel an exact circular arc, the indicator will travel in an approximate straight line, with a degree of accuracy depending on the variation of the trace from the circular arc.

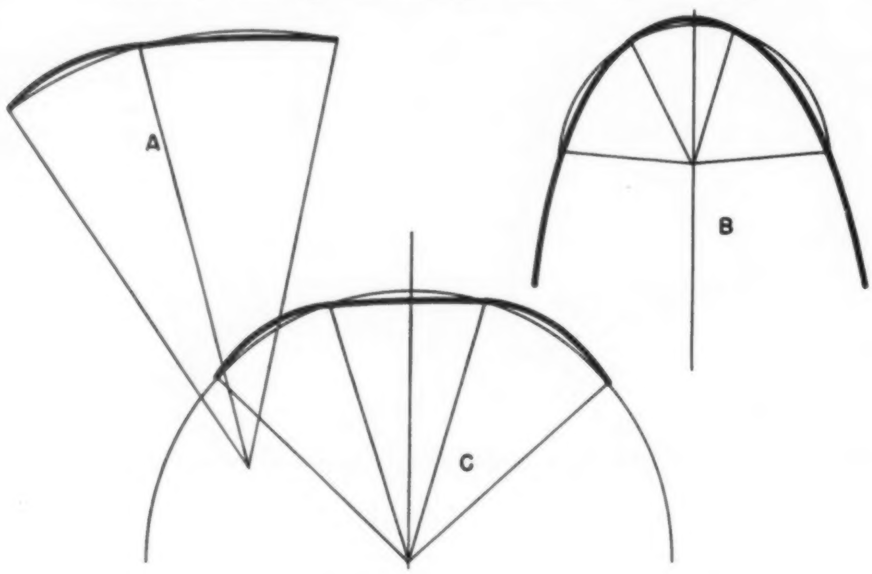
Alternative points in addition to *P,* all rigidly attached to and moving with the indicator link *DS,* are shown in *Fig.* 10. For examining the trace of these points as *S* moves to S_1, a useful tool is an overlay of concentric circles such as those shown with their centers at *A.* As illustrated, the trace F-F_1 gives a close arc match; if a crank of length *AF* is connected to the indicator link at *F,* the resulting four-bar linkage would drive the point *S* in an approximate straight line. The center of curvature may also be

found by three-point circle construction procedure as shown at B-E-E_1.

Any trace generated can be used as a control point path and an approximating circular arc constructed, but many will be found to be too inaccurate to suit the intended use; others such as *E, Fig.* 10, will be found to pass through dead center positions, locking the mechanism. In this system, a trace and its approximate circular arc may touch in only three places rather than four as in the Burmester method. *Fig.* 11 shows the complete 360-degree traces of a number of points on the slider crank used in *Fig.* 10. These traces, in general, form two ovate loops, passing through no more than four places of maximum radius of curvature and four places of minimum radius. Only at a place of minimum or maximum radius of curvature is it possible to approximate the curve with a circular arc touching in four places, while there are many portions of the curves where circular arcs can touch in three places.

To illustrate this, shown exaggerated in *Fig.* 12*a* is a typical trace having a spiral-like shape with a radius of curvature smaller on one end than on the other. A circular arc is shown touching the trace at three points. This type of curve can *only* touch a circular arc in three places. *Fig.* 12*b* illustrates a typical ovate trace having a point of minimum radius of curvature bounded by a larger radius of curvature on each side. *Fig.* 12*c* shows another ovate trace having a point of maximum radius. *Fig.* 12*b* and *c* each have circular arcs which touch the traces at four points.

Fig. 12—Unsymmetrical trace, *a*, which can touch a circular arc at only three points. Symmetry at points of minimum and maximum curvature, *b* and *c*, permit touching a circular arc at four points



When a trace is replaced by a circular arc of matching radius (that is, when a control crank is substituted) the indicator path will be forced away from the ideal straight line and into a curve touching the straight line at the same number of points as are touched in the arc-match. Good overall fit between a trace and its approximated circular arc, not the number of points touched, is important to produce accurate straight-line motion.

In *Fig.* 13 the Thompson indicator mechanism has been developed and the traces of a number of points

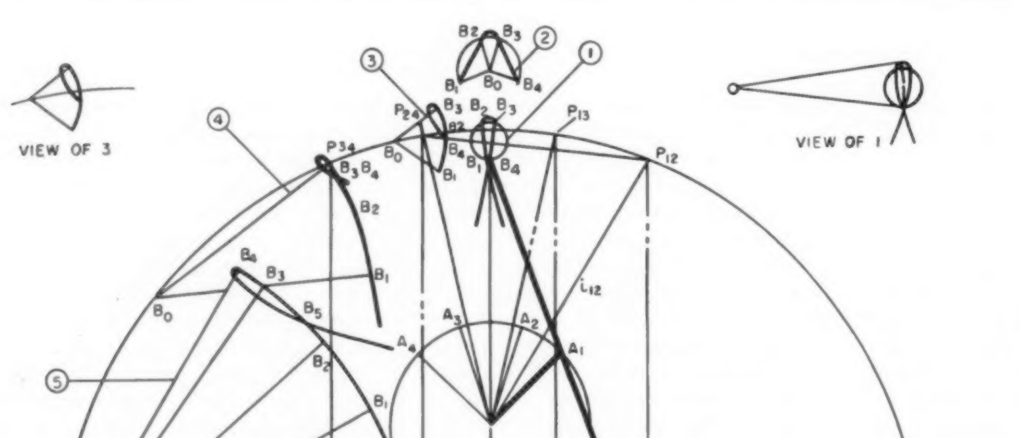


Fig. 13—Thompson indicator mechanism, showing plotted traces of several points on the indicator link

plotted. At (1) is the trace of the control point found by using the equations of *Fig.* 5. This forms a long ovate loop, crossing the center line at each end of the indicator travel. The small circle is the arc of the crank developed for this point by Burmester methods. Though coinciding with the point trace at four places B_1, B_2, B_3, and B_4, and thereby causing the indicator to be on the straight line at the corresponding four points, this solution causes a binding action between B_2 and B_3. The arc is farther off the trace at most other points than is the Thompson control crank, the connecting point of which travels vertically inside the trace loop.

Some variations of this mechanism use a slide to guide this point in a straight line, as was mentioned in discussing the elliptic trammel but this is only very slightly closer to the actual trace than is the control crank arc. At (2) the four-point trace would lock the mechanism at dead center. This is a poor choice for either method. At (3) a crank which bisects the loop will distribute the deviation more evenly over the entire indicator travel instead of concentrating it between B_3 and B_4. This can still be a four point match. The four-point Burmester crank at (4) and (5) probably cannot be improved upon by arc-match methods.

One shortcoming of the arc-match method of linkage design as outlined thus far is the lack of a means for directly finding a control crank when the desired position of the control crank pivot has been established. The answer to this problem is based on the proposition, *the velocities and accelerations of two points relative to each other are equal and opposite.* Therefore if the link is made stationary and the machine base rotated about the link, the trace of the control crank pivot relative to the link would be equal and opposite to the trace of the control point relative to the machine base.

The indicator link *DS* and a point *P* which corresponds to the point used in describing the arc-match system are traced on transparent paper, *Fig.* 14*a*. *Fig.* 14*b* depicts the machine base for the same development, including the straight line path *S-S'*, the drive point path *D-D'* and the control point pivot *R*. Also added is the point *C* which is the desired location of the control crank pivot on the machine base.

In *Fig.* 15 the trace of the point *P* is shown developed by graphical overlay methods with the machine base moved over the link to develop the trace of *P* relative to the base. The center of this trace arc is then found

(a)

(b)

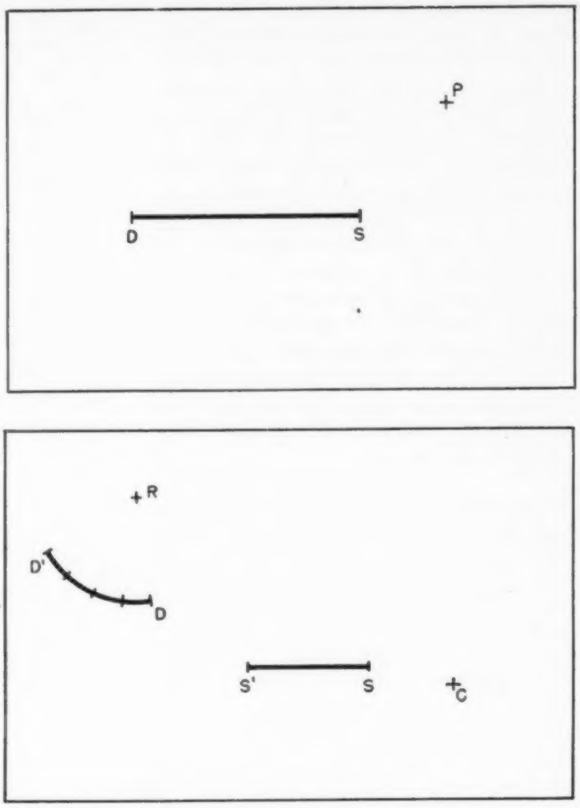


Fig. 14—Indicator link on transparent paper, *a*, and stationary part of mechanism, *b*

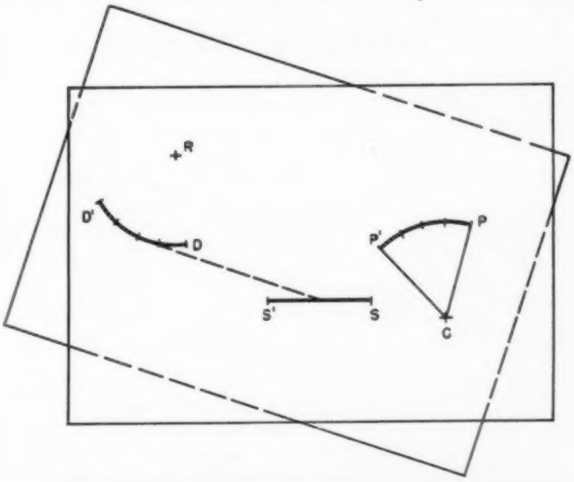


Fig. 15—Graphical overlay of *Fig.* 14*a* on *Fig.* 14*b*. Successive positions develop trace of *P* and hence location of center *C*

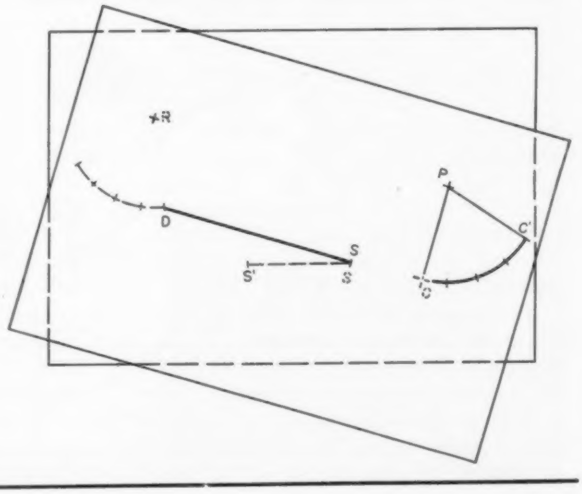


Fig. 16—Graphical overlay of *Fig.* 14*a* on *Fig.* 14*b* with trace of point *C* plotted. This trace is equal and opposite to that of point *P* relative to the machine base

to be at C.

To reverse this procedure and find the control point to operate with a control crank pivoted at C, the link sheet is placed over the machine base as in *Fig.* 16 and the trace of the point C relative to the link is plotted. This trace of the point C is equal and opposite to the trace of the point P relative to the machine base. The center of this arc trace will be at P, which is the point on the link to which a control crank pivoted at C would have to be connected to form the approximate straight-line mechanism. Selection of this point is no guarantee of an accurate arc-trace match although the arc will match with the same degree of accuracy as it will the trace of the crank pivot relative to the link.

Summary: The linkage designer has four tools at his disposal:

1. Prior art may help, but is limited.
2. A prepared atlas of curves is useful if the range of curves available covers the desired range of design, without growing too large.
3. The Burmester theory of linkage design is a graphical method of direct approach for finding all possible cranks which will cause the indicator to touch the desired straight line at four selected points.
4. The most general method of solution is called by the authors the *arc-match method*. This is a method of graphically searching for a secondary (control) crank center by comparing generated curves with circular arcs.

This system is not necessarily limited to mechanisms for generating straight lines but may be used where other curves are to be generated.

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Proportional Control System

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FOR MANY years the blending of liquids accurately was accomplished almost completely by batch processing with the use of expensive scales and tanks. Today the blending of the basic constituents of lubricating oils, vegetable oils, soaps, liquid food products, and generally speaking any liquids, can be accomplished with an automatic-control system. The necessity for measuring, weighing, and multiple handling of liquid products no longer exists.

The advantages afforded in maintaining a standard of quality control and the elimination of possible human error in system control economically justify automatic blending systems.

The proportional control system to be described was developed as most products—step by step, depending upon the requirements of industry.

A basic system required for blending of three liquids is shown in *Fig.* 1. Meters 1, 2 and 3 are the primary measuring elements of the system and are of the reciprocating piston type. These primary elements in many cases are accurate to within 0.1 per cent of reading depending upon the operating conditions of the process. Since the principal concern is the proportional control system, details of operation of the primary element will not be considered.

In addition to the primary metering elements the following components are shown in *Fig.* 1:

A—Balanced control valve
B—Differential adder
C—Control nut
D—Control arm used to operate control valve *A*
E—Proportion selectors and control
F—Limit switch for pump or auxiliary controls
G—Coupling for differential adder *B* to proportion selector *E*

These components form the basic building blocks of the control system.

An explanation of the system in *Fig.* 1 will illustrate more clearly the principle of operation. The explanation will be simplified to show the operation of the system rather than of the individual components. Three liquids can be blended with this system at any one time, and this is for purposes of explanation only, for no theoretical limit exists as to the number of different liquids that can be blended in one simultaneous operation. A practical limit based on the economics of the system as well as the design does exist, however. An assumption is also made that the pumps, used to supply the meters, the primary metering elements, and the valves are sized to meet the requirements of the system.

Assume that three products are to be blended: 50 per cent of product A, 30½ per cent of product B, and 19½ per cent of product C. Before the blending process is started proportion selectors E are set to 50 on meter 1, 30½ on meter 2, and 19½ on meter 3. For purposes of analysis the steady-state conditions will be considered in preference to the transient response. When the pumps feeding the metering elements are put in operation, liquid flows through the metering elements. The output of each meter is a shaft speed directly proportional to the quantity of liquid flowing through the respective meter. The output of each meter shaft is coupled to differential adders B and control nut C. The output of differential adders B is thus the sum of the shaft speeds of meters 1, 2 and 3. The output of the last differential adder is coupled through G to proportion selector E. The shaft coupling proportion selectors E thus represent a 100 per cent shaft whose speed is equivalent to or a function of the output of the differential adders.

When proportion selectors E were adjusted at the start of the process a gear rationing device was so activated that the output speed of the proportion selectors coupled to control nut C is equal to the output speed of the meters coupled through the vertical shaft of the differential adder. Thus, control nut C will remain in a stationary position if the output speed of the differential adders is equal to the output speed of the proportion selectors. If, for some unknown reason, the output of meter 1 should decrease, (1) the output speed of the last differential adder will also decrease, (2) the speed of the 100 per cent shaft will decrease, (3) the output speed of each proportion selector will be decreased, and (4) the control nut will move

in a direction to decrease the output of meters 2 and 3, through operation of control valve *A*, but still maintaining a constant proportion. If the output of any one meter should exceed the control range limit switch *F* will operate and inactivate the system or sound a warning. A further explanation of the individual components will follow, giving the detailed analysis of the system.

Actual Flow Control: *Fig.* 2 shows a typical system installation where five liquids are blended in proportion to form a final product. The metering equipment with the basic control mechanisms is located behind the panels. The totalizers for each individual constituent being metered are located in the upper exposed portion and indicate the number of gallons of liquid that has passed through the system. The counter at the rear of the center panel is coupled to the output of the last differential adder of *Fig.* 1 and indicates the total number of gallons of liquid that have passed through all meters. A predetermining type counter is shown in the foreground of the center section.

In this manner batching can be accomplished with the provision for automatic shut-off after a predetermined number of gallons of liquid have passed through the system. The upper control sections just above center indicate input and output pressure, temperature, and valve position. If the pressure remains constant, then valve position, for any one set of standard conditions, is analogous to rate of flow of liquid through the system.

The proportional control system thus far considered offers proportional control only. With some modifications the system can be made to offer "reset" action. Proportional control plus reset action, as here considered, would not only offer control but would allow for a narrower control range irrespective of variation in line pressure of any one of the metering systems.

Method of Operation: The control system, as described, gives a positive, automatic, and precise method of controlling several variables in given proportion to one another. The operation is limited only by the physical configuration of the system and is adaptable to almost any set of conditions. The same method can be used for controlling functions in proportion providing the measured variable can be translated into an equivalent shaft rotation. Thus, shaft rotation becomes an analog of the measured variable. In considering the technical details of the system no consideration will be given to the loads on various members. The unit can be designed to meet the requirements of miniaturized systems where minute loads are transmitted or ruggedized to the degree to allow a

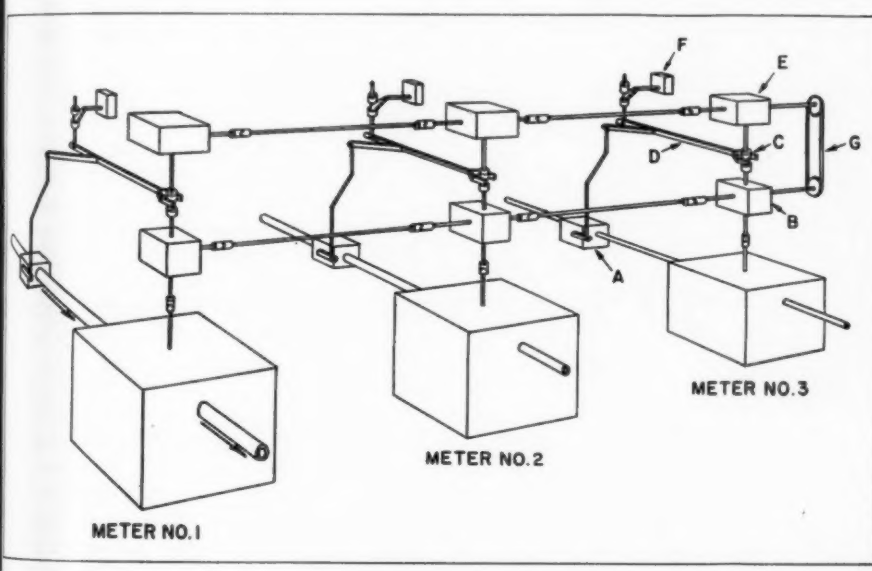

Fig. 1 — Above — Basic system for proportional control

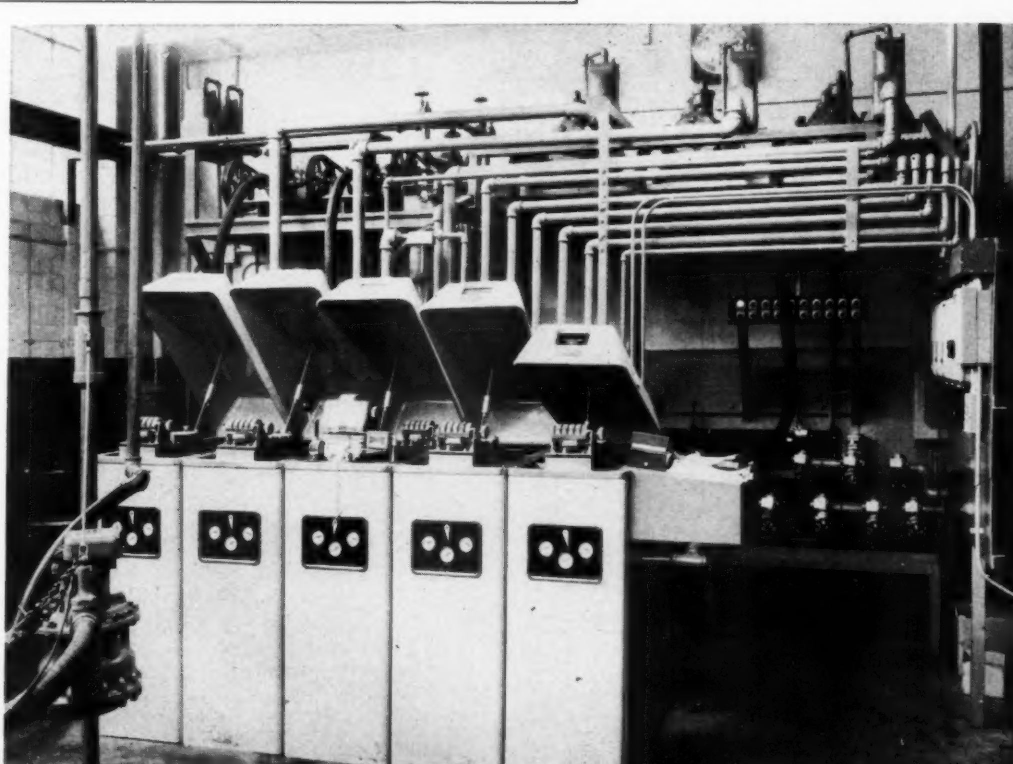

Fig. 2—Right — Typical five-unit installation

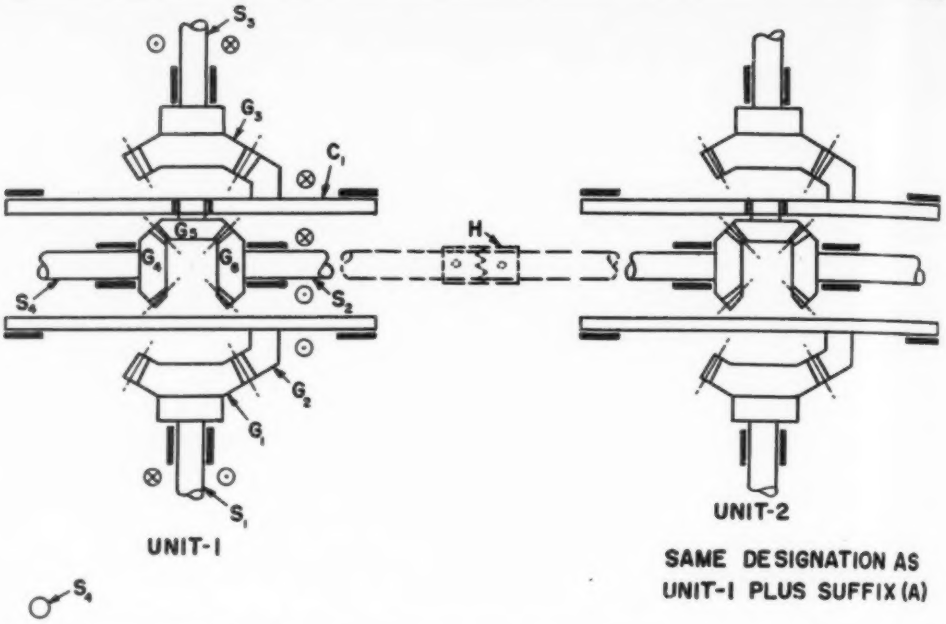

Fig. 3 — Differential as used in system for adding shaft speeds

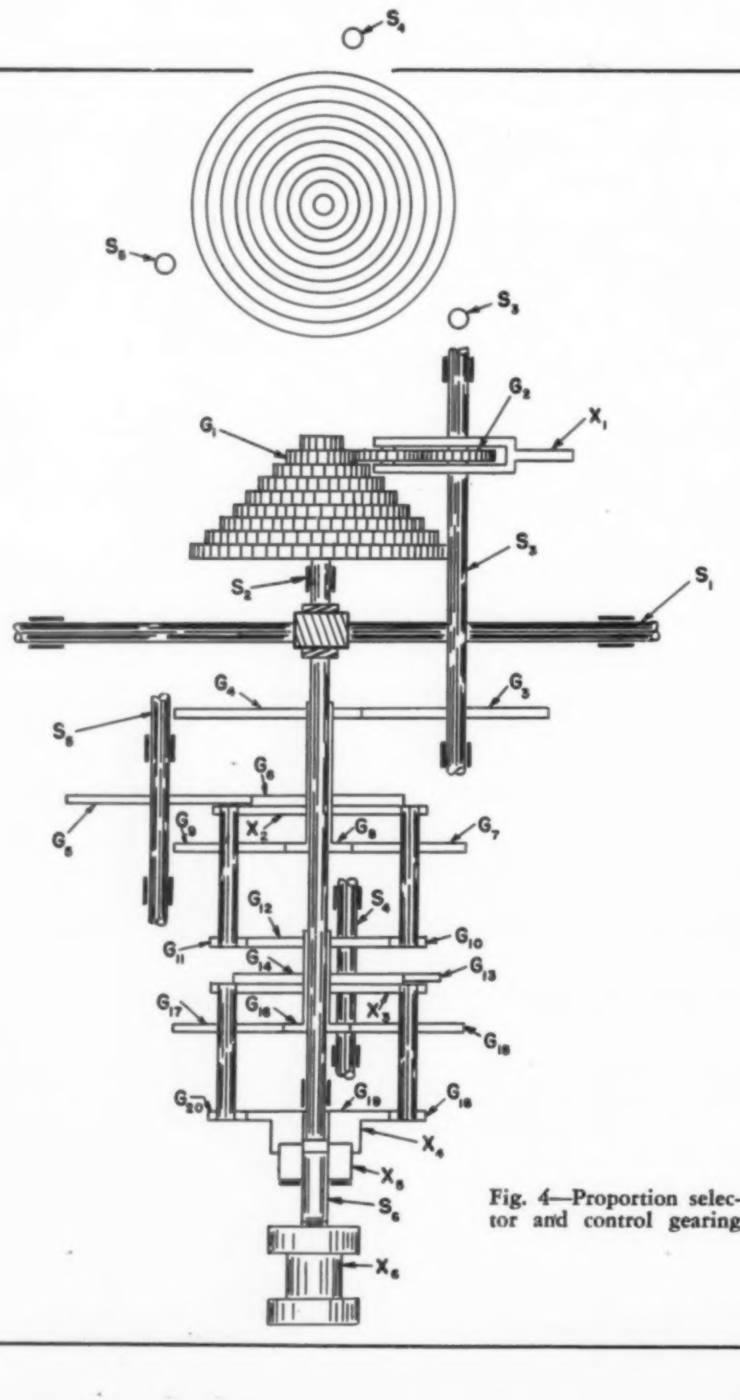

Fig. 4—Proportion selector and control gearing

transfer of considerable power through the components.

The requirements of the control system are the differential adders and the proportion selectors, with the associated drives and linkages. *Fig.* 3 shows two bevel gear differentials connected in tandem for purposes of adding two rotations. The gear-change mechanism, required for reversing the direction of the output shaft prior to coupling to the second differential, has been omitted for simplicity. It should be noted, however, that the direction of the output shaft of the first differential adder must be reversed if the output of the second differential adder is to be the sum of the output of the first plus the rotation imparted by action of the second input shaft.

The design of the differential can be such as to meet the requirements of the system. It can be considered as a linear cell where each of the parameters is a rotation. No consideration is given to bearing location, except as indicated, for the assumption is made that the reader is familiar with the fundamentals and techniques used in differential design.

Referring to *Fig.* 3, a bevel gear G_1 on shaft S_1 is coupled to gear G_2 mounted on an essentially cylindrical cage C_1 and coupled to gear G_3 mounted on shaft S_3. Since no motion is coupled to the first differential, shaft S_4 is stationary. In the application shown a ratio of one to two exists between G_1 and G_2; thus, cage C_1 rotates 180 degrees for each rotation of S_1.

Differential cage C_1 is designed to include a fixed shaft which is in a plane perpendicular to the axis of

the cage and cutting the center line of shafts S_1 and S_3. A planetary miter pinion G_5 is mounted on the fixed shaft and meshes with gears G_4 and G_6. Since a ratio of one exists between G_4, G_5 and G_6, the speed of S_2 is equal to the speed of S_4 when the cage is stationary. Since bevel gear differentials are independent of the ratio of the bevel gears, the motion is transmitted through a one to one ratio but in the opposite sense as indicated in *Fig.* 3. Summarizing the conditions of *Fig.* 3:

$$N_{S1} = -N_{S3}$$
$$N_{S1} = 0.5N_{C1}$$
$$N_{S2} = N_{S1} \pm N_{S4}$$
$$N_{S1} = N_{S2}$$

where N is equal to the speed of rotation using the conventions shown. If the output of S_2 is reversed and fed through coupling H to S_{4A} the output of S_{2A} will be $N_{S2} + N_{S1A}$.

Any number of differentials may be connected in this manner and the output will be the sum of all the drive shafts prefixed by S_1. If any S_1 shaft is not rotating, a straight-through motion will be transmitted through the bevel gearing within the differential cage. The shafts prefixed by S_3 will be operating at the same speed as the S_1 shafts but in the opposite sense.

The proportion selector with the associated gearing is shown in *Fig.* 4. Basically this unit is a variable-speed drive in which the outfit of three shafts, for example, one for units, tens, and hundreds, are coupled respectively to three spur-gear differentials in order to obtain one shaft output equal to the sum of the three shaft speeds.

Shaft S_1 of *Fig.* 4 is connected to the output of the last differential of *Fig.* 3. It is thus the base for operation of the speed-change mechanism. Shaft S_1 carries a helical gear which is coupled through the helical gear on S_2 to drive cone gear G_1. A series of gears G_2 is mounted on a rotatable and slideable arm X_1.

These gears are so arranged that they can be engaged along any one of the positions of the cone gear. Thus by proper gearing, the output of shaft S_3 can be any direct function of the rotation of S_1. In *Fig.* 4 three shafts can be coupled to the cone gear. Only one shaft is shown in operation for simplicity. If shaft S_1 is the base speed, then the sum output of shafts S_3, S_4, and S_5 will be a function of S_1. For purposes of explanation three digital shafts S_3, S_4, and S_5 are considered. Additional digits can be added providing sufficient space is available.

The output of shaft S_1 is coupled through G_3 to G_4 which is fixed to the hub of gear G_8. A planetary carrier X_2 is allowed to rotate freely, on the hub of gear G_8. The planetary carrier has mounted on a diameter two planetary pinions G_7 and G_9. Gears G_7 and G_9 mesh with G_8.

Gears G_{10} and G_{11} mesh with G_{12} which is fixed to the hub of G_{16}. The planetary carrier X_2 has a gear G_6 mounted concentric with its axis. Gear G_5 is coupled through shaft S_5 which is driven by the cone-gear assembly. Thus the motion imparted by G_3 is added to the motion of G_5 with the result that G_8 and G_{12} operate at a speed equal to the sum of the speeds of rotation of S_3 and S_5.

A second planetary carrier X_3 can rotate freely on the hub of gears G_{12} and G_{16}. Gear G_{14} is also fixed to this second planetary carrier. Gear G_{13} fastened to shaft S_4 is also driven by a variable speed from the cone gear. Gears G_{15} and G_{17} are also mounted on the carrier and mesh with G_{16}. G_{18} mounted on the same

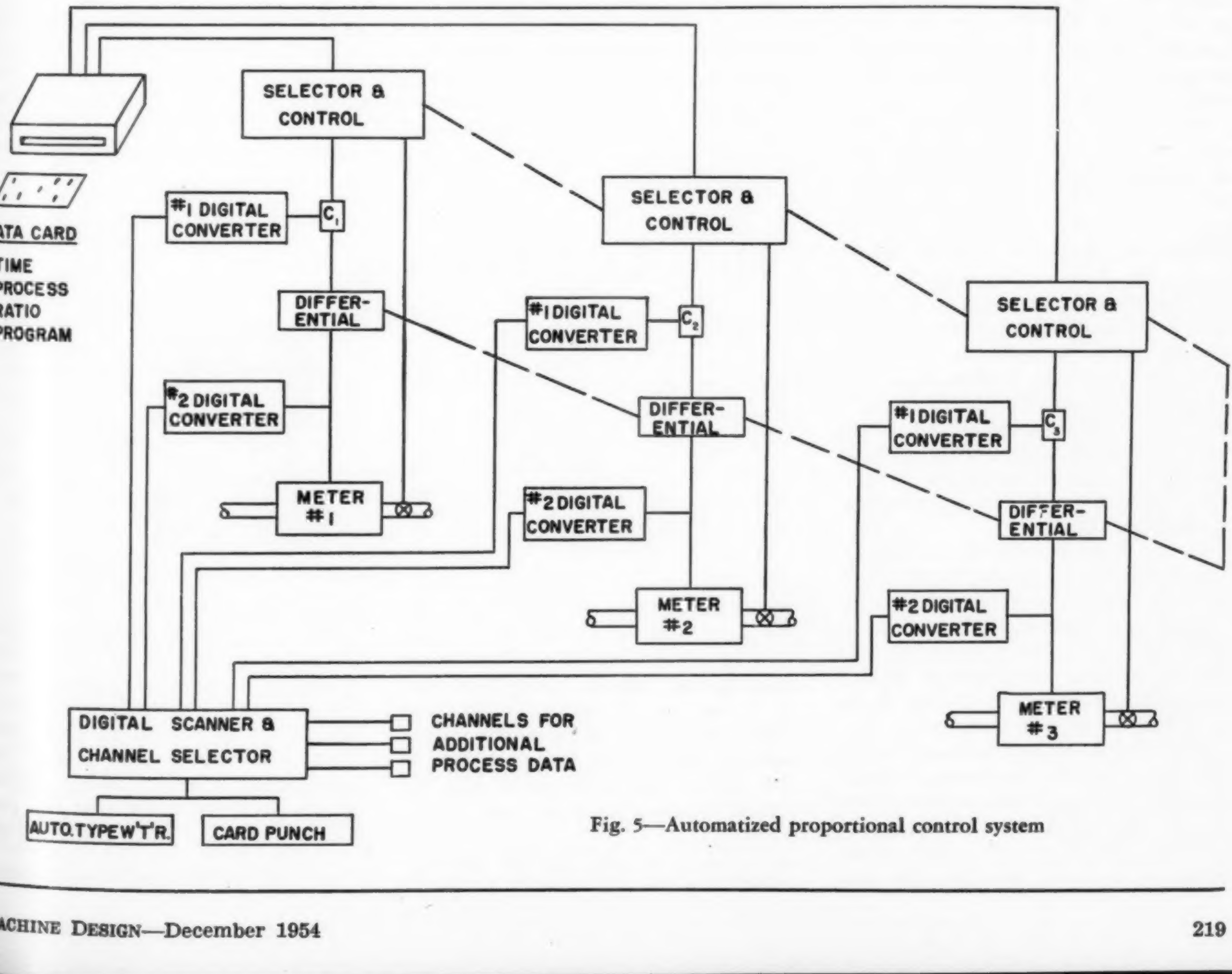

Fig. 5—Automatized proportional control system

shaft with G_{15} and G_{20} mounted on the shaft which carries G_{17} are in mesh with G_{19} which is fixed to socket member X_4 and which rotates freely on shaft S_2. Shaft S_6 is threaded into the upper portion of the control nut X_6 and is coupled to the control mechanism through square flange X_5. Thus the rotation of gear G_{19} is equal to the sum of the rotation of S_3, S_4 and S_5, determined by the settings of the G_2 series gears which would also be mounted in some modified form and in various ratios on shafts S_4 and S_5. The gear ratios of the G_2 drives can vary depending upon the ratio factor of the shafts S_3, S_4 and S_5.

The addition of the shaft speeds as shown in *Fig.* 4 is accomplished through the two spur-gear differential adders. The same result can be accomplished through the use of bevel-gear differentials, but the advantage of the system shown in *Fig.* 4 is the ability to transfer a ratio other than one in the same direction of motion. The equations of the differentials shown are:

$$N_{G12} = QN_{G4} + (1 - Q)\, N_{G5} \qquad (1)$$

$$N_{G19} = QN_{G16} + (1 - Q)\, NG_{13} \qquad (2)$$

where N represents the total number of degrees of rotation and Q is a factor depending upon the gear ratios. The fact that Q can be a variable for any series of differentials makes it desirable for additive applications, as shown. In Equations 1 and 2 Q may take different values in both differentials. As a result multiple ratio factors are obtained easily.

The action of the proportion control has been described briefly but an example may help to clarify the explanation. The 100 per cent shaft operates the proportion control through S_1 of *Fig.* 4. If the speed of S_1 is 100 rpm, cone gear G_1 will operate at 100 rpm. If the proportion selector was originally set for 48.5 per cent by location of the G_2 gears on shafts S_3, S_4 and S_5 to the proper level, then the output of gear G_{19} will be 48.5 rpm. If the meter that this particular control unit is associated with is operating at 48.5 rpm, no motion will be imparted to control nut X_6.

If for some reason the output of the meter should be decreased to 45 rpm the 100 per cent shaft will now operate at 96.5 rpm. This change in speed will drive the proportion control mechanisms of the other meters at a reduced rate of speed, and cause a motion to be imparted to the control nuts to decrease the flow through the valves by the bar linkage mechanisms. Likewise the valve of the meter responsible for the change in balance conditions will open in an effort to increase the flow. The correction response time, or the transient time, is a function of the inertia of the system and the sensitivity of the valve operation.

Automatized System: The system of control thus far described is only a semiautomatic control system in the true sense of the word. What are some of the possibilities of the application of this system to a completely automatized operation? What are the possibilities of using electronic techniques to accomplish this goal? Can the system be designed with sufficient flexibility?

These are questions which will be answered in the future. Keeping in mind the accuracy of the primary elements, 0.1 per cent as a target, the system offers many possibilities. Most electronic ratio control is inaccurate when compared to 0.1 per cent. Ratio control to within 1.0 per cent is about the best that can generally be expected.

Fig. 5 is an example of what may be expected in the future. A liquid-flow system is used for purposes of description only, for if the variable can be operated on in such a manner so as to give an analogous shaft rotation, the same system of control could be used with some slight modification. *Fig.* 5 contains the basic building blocks as shown in *Fig.* 1 with the addition of automatic controls. The process is controlled by means of punched cards, tape or any other means available for storing information. The data card as shown will contain sufficient information to control automatically the time, the particular process to be used, the ratio of the basic constituents, the quantity to be delivered and the program of operations to be followed. The time punch on the data card will initiate the signal to begin the process. The selector and control mechanisms will be actuated from the information that appears on the punched card. These problems are relatively simple and can be solved by using standard engineering techniques. The valve shown in *Fig.* 5 is either a pneumatically or electrically operated one in preference to the mechanical balanced type. The original counting means is either replaced or modified to include a digital converter for purposes of converting the analog data.

Position of the control nuts shown as C_1, C_2 and C_3 is an analog of the rate of flow of liquid through the system. This output can be fed through a digital converter and then into the scanner and selector. The equipment associated with each meter is similar and is a duplicate of the first.

The digital scanner and channel selector is the nerve center of the system. By use of an automatic typewriter, card punch, or other data storage devices, the data can be presented in a tabular form for future use. The system is versatile since by using the proper interlinks, pneumatic or electric signals can be converted into a digital form. The logging of the data can be arranged for at preset intervals of time depending upon the process. Additional variables of the physical system can also be fed to the scanner and selector for logging and use in control.

Beveloid Gearing

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BEVELOID* gears represent the most general form of involute gearing. They can be engaged with spur gears, helical gears, worms, racks and, of course, other Beveloid gears. They can be used with intersecting, parallel or skew shafts in the same manner as bevel, spur or helical gears. They are insensitive to mounting errors.

Beveloid gearing represents a revolutionary extension of the theory of tapered-tooth involute gearing. This type of gearing which was originally thought to be limited to small shaft angles has been presented under the designation, "conical involute gears," by Merritt[1] who stated that this gear had "valuable, but little-explored

*Registered U. S. Patent Office, manufactured under U. S. Patent 2,607,175; other patents pending.

[1]References are tabulated at end of article.

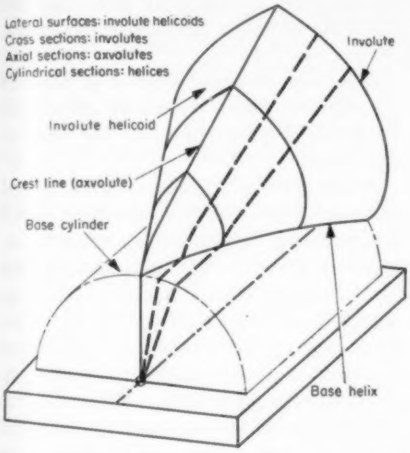


Fig. 1—Model of the straight beveloid tooth (theoretical). Base helix only is shown. Sketch, courtesy Dr. W. F. Vogel, Wayne University, Detroit

possibilities." These gears were not looked upon as a method of providing a high degree of precision. Instead, they were regarded as an expedient to solve the rather rare problem of small shaft angles.

The full potentialities of these gears remained unexplored until hitherto unknown characteristics were discovered through experimental and analytical investigations. The widely adaptable gearing system resulting from this discovery—Beveloid gearing— offers advantages in precision, versatility and backlash control that were not anticipated in the original concept of tapered tooth involute gearing.

Definition: The Beveloid gear is an involute gear with tapered tooth thickness, tapered root and, in most cases, tapered outside diameter. All sections normal to the axis have a common base-circle diameter and thus the same involutes, but the tooth thickness at any diameter increases linearly from the front face to the back face of the gear. The gear has the general appearance of a bevel gear, but each transverse section represents a spur gear.

Fig. 1 shows the geometric characteristics of the Beveloid tooth surfaces. The origins of all involutes are along base helices, usually right-hand on one side and left-hand on the opposite side of each tooth. The tooth surfaces are, therefore, involute helicoids, which intersect any cylindrical surface along a helix. Axial sections are axvolutes, as defined by Vogel[2].

If the helices of opposite tooth surfaces are the same, but of opposite hand, the gear is designated as a *straight* Beveloid gear. If the opposite helices are not the same, the gear is an *oblique* Beveloid gear. The opposite sides of straight Beveloid gear teeth intersect along axvolutes. Oblique Beveloid gears may have not only different helix angles on opposite tooth sides, but also different base diameters with the same or different base helix angles. This article deals primarily with straight Beveloid gears.

Fig. 2 shows the Beveloid tooth in its relation to the involute helicoid tooth surfaces of *Fig.* 1.

Fig. 3 shows the general appearance of the Beveloid gear, which resembles a bevel gear. Since all involutes are developed from base cylinders and meshing conditions are studied on the basis of rolling cylinders, the Beveloid gear could be considered as a "cylindrical bevel" gear even though this combination of terms appears somewhat paradoxical.

Advantages: Beveloid gearing offers the following advantages in use, design and manufacture.

Accurate Transmission of Motion: Beveloid gears can be manufactured to precision tolerances in the magnitude of 0.0002-inch total composite error, regardless of the volume of production. Manufacturing variations in cone angle, tooth thickness or helix do not affect the meshing action with the mating gear.

Unlimited Meshing Combinations: The Beveloid gear is conjugate to a rack. It therefore operates with all gears derived from the same rack, such as spur gears, helical gears, involute worms, racks and, of course, other Beveloid gears. It permits a vastly wider variety of gear combinations than any other type of gearing.

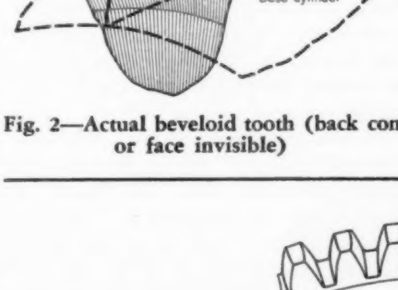


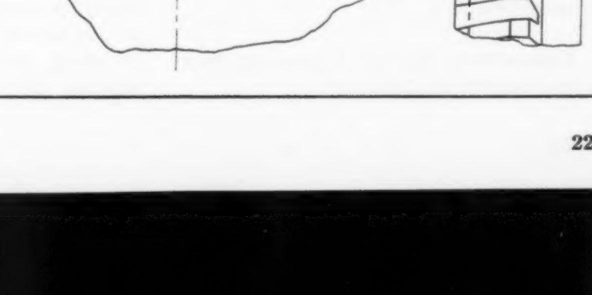
Fig. 2—Actual beveloid tooth (back cone or face invisible)

Freedom of Gear Arrangements: Beveloid gears are derived from the straight linear rack of the involute system where there is no center or vertex, while conventional bevel gears are derived from a circular rack, the center of which is the vertex and the radius of which is the cone distance of the bevel gears. Therefore, mating Beveloid gears need not have a common vertex and their "Beveloid" or cone angles are independent of shaft angle and gear ratio. All Beveloid gears of the same pitch and pressure angle are conjugate without requiring an equal cone distance. Any number of different gear ratios can be obtained by take-offs from a common Beveloid gear at any desired shaft angle.

Elimination of Mounting Errors Effects: (1) The mounting distance of Beveloid gears is not critical. Precise bore and thrust face relations are not required. Beveloids can be adjusted axially without any effect on the accuracy and uniformity of transmitted motion. (2) Beveloid gears designed for intersecting axes will operate correctly even if the axes of mating gears are not in the same plane. Relative shift of the axes in any direction is permissible. (3) Beveloid gears permit deviations of the shaft angle, and even allow the angle to vary while the gears are in operation.

Elimination or Control of Backlash: Whether Beveloid gears operate with parallel, intersecting or skew axes, they can always be brought into tight mesh through adjustment because there is no condition governing their relative position. Therefore, backlash can always be eliminated, or any desired amount of backlash can be obtained, by sliding the gears on their shafts. Split gear design and floating center distance are avoided.

Fig. 3 — Beveloid gear



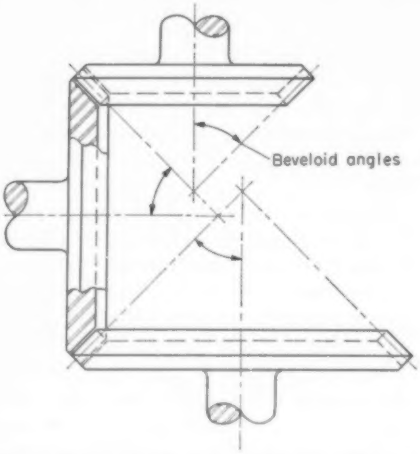


Fig. 4—Beveloid combination with intersecting axes. Design not limited by common vertex

Point Bearing: Tooth contact of Beveloid gears on intersecting or skew shafts is theoretically confined to a point, thus placing a limit on permissible loads. Contact conditions are the same as with any crossed axes gearing when both members are generated from a basic rack or other generating gear. Crossed axes gears have line contact only when the generating gear duplicates one of the mating gears ("Formate" gear).

Surface durability can be increased by using hardened Beveloid gears. Such gears on intersecting shafts have been employed successfully in precision grinding machinery and have rendered useful service for many years without requiring replacement.

When Beveloid gears are arranged with parallel axes, or when a Beveloid gear engages a rack, the teeth have line contact. Load-carrying ability and wear life will equal those of spur and helical gears with parallel axes. When the shaft angle is small, the tooth bearing of Beveloid gears approaches line contact.

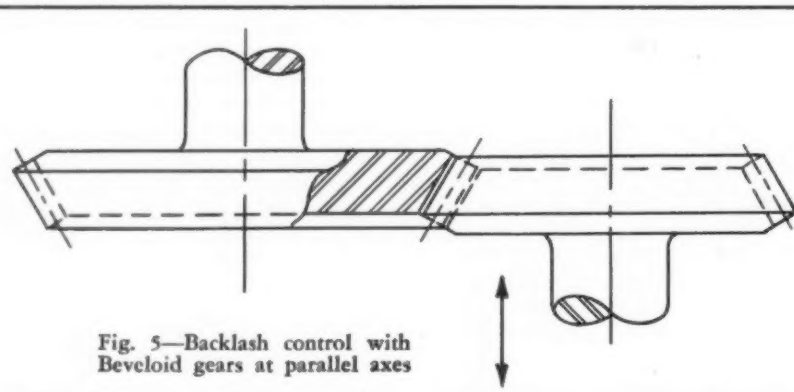


Fig. 5—Backlash control with Beveloid gears at parallel axes

Centralized Tooth Bearing: Beveloid gears are designed so that the tooth bearing occurs at or near the center of the tooth surfaces. The crowning effect is obtained as a result of the inherent tooth geometry.

Reduced Gear Noise and Smooth Operation: Beveloid gears operate quieter than conventional bevel and cylindrical gears because tooth bearing is localized. This minimizes interferences and results in smooth operation.

Precision Dimensional Control: Beveloid gears are subject to both analytical and functional inspection. Since the Beveloid gear is composed of spur gear sections, progressively diminishing in tooth thickness and outside diameter, geometric characteristics are established with relative ease and are controlled with substantially the same inspection equipment as used for spur gears. Tooth elements such as profile, spacing and tooth thickness can, therefore, be checked to the same degree of accuracy. The rolling action can be tested by means of standard master spur gears.

Limitations: Beveloid gearing has two inherent limitations:

Undercutting of Gear Teeth: The design of Beveloid gears requires careful attention to undercut conditions so that sufficient involute tooth surface is available. The undercut becomes critical when the number of teeth is small and the Beveloid or cone angle is large. The minimum number of teeth which can be used increases, therefore, with the Beveloid angle.

In view of the freedom in the selection of Beveloid angles, which arises from the fact that the gears are not limited by a common vertex, it is possible to avoid or minimize undercutting by using small Beveloid angles for pinions with low numbers of teeth. This and other means are available to minimize undercut conditions. In addition, it should be borne in mind that a greater amount of undercut can be tolerated on Beveloid gearing than on spur or helical gears because in Beveloids the maximum undercut is confined to the front of the gear and may not interfere with the limited contact area.

Beveloid Applications: The variety of ways in which Beveloid gears can be used is suggested by the following cases:

Beveloid Combinations with Intersecting Axes: *Fig.* 4 shows a combination of Beveloid gears with intersecting axes and illustrates the fact that Beveloid gears need no common vertex. This three-gear arrangement would have to be enlarged to a four-gear set, if conventional bevel gears were used. Conventional bevel gears with equal pitch and pressure angle are not interchangeable, unless they are generated from a circular rack with the same pitch radius so that their cone distances are equal. Since the cone distance has no significance with Beveloid gears, all Beveloid gears with the same pitch and pressure angle are interchangeable. It is possible, therefore, to produce a series of miter Beveloid gears with 45-degree Beveloid angles and different numbers of teeth that will open up a wide range of gear ratios from these standard elements.

Beveloid Gears on Parallel Axes: *Fig.* 5 shows another arrangement, impossible with conventional bevel gears, in which the axes of mating Beveloid gears are parallel. Beveloid gear sections perpendicular to the axis have the same geometry as cylindrical involute spur gears, even though the tooth thickness changes from the back to the front face. Hence, thick tooth sections of one Beveloid gear mesh with thin tooth sections of the mating gear. Since each section operates in the same manner as a spur gear, the tooth

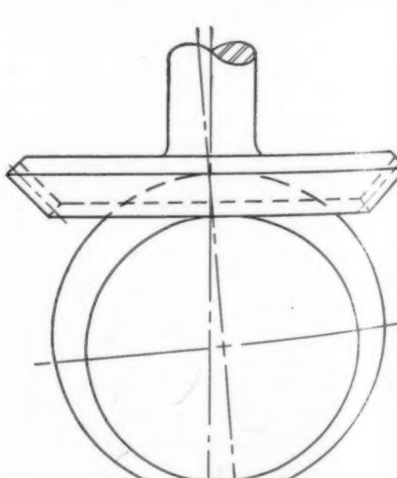


Fig. 6—Beveloid gears with skew axes

contact extends over the whole face width.

The amount of backlash can be controlled by axial adjustment. Zero backlash can be obtained with fixed center distance. The angularity of the Beveloid gears is exaggerated in *Fig.* 5. To obtain sensitivity in the control of backlash, considerably smaller angles would be used.

Beveloids on parallel axes can be used to simplify gear systems and make them more compact. For example, if a right-angle bevel-gear drive and a spur-gear train come off the same shaft, Beveloids can be used for both drives. One Beveloid gear can serve in both the right-angle and the parallel-axes gear drives, thus eliminating one gear.

Beveloid Gears with Skew Axes: The arrangement illustrated in *Fig.* 6 shows an application for crossed axes. In principle, cylindrical helical gears can be used for crossed axes unless the normal distance between the axes is very small, as in *Fig.* 6. But even with a larger distance, the Beveloid gear is superior because it permits control and elimination of backlash through axial adjustment, without changing axis location. Helical gears offer no advantage for crossed axes because point bearing occurs in the same manner as with Beveloid gears. In all applications of crossed axes in which backlash control is desired, Beveloid gears offer a solution.

Multiple Beveloid Take-Off with Coplanar Axes: The possibility of two take-offs arranged in the same axial plane and operating with different rolling diameters of the common Beveloid drive gear is illustrated in *Fig.* 7. The same arrangement with conventional bevel gearing would be hampered by the requirement that the relation of pitch cone angles must be in harmony with the gear ratio. Beveloid gears are free of this requirement and permit a much wider range of shaft angles.

Beveloid Differential: *Fig.* 8 shows a typical Beveloid application for servomechanisms or computing devices. The use of Beveloid gearing in differentials offers the advantage of complete backlash elimination. This is accomplished by axial adjustment of opposite gears to a tight mesh engagement. The use of the same procedure with conventional bevel gears would result in improper meshing action since axial movement of the bevel gears would cause a departure from the required mounting distance.

Beveloid in Mesh with Spur Gear: Versatility of the Beveloid gear is demonstrated in the following illustrations, the first of which, *Fig.* 9,

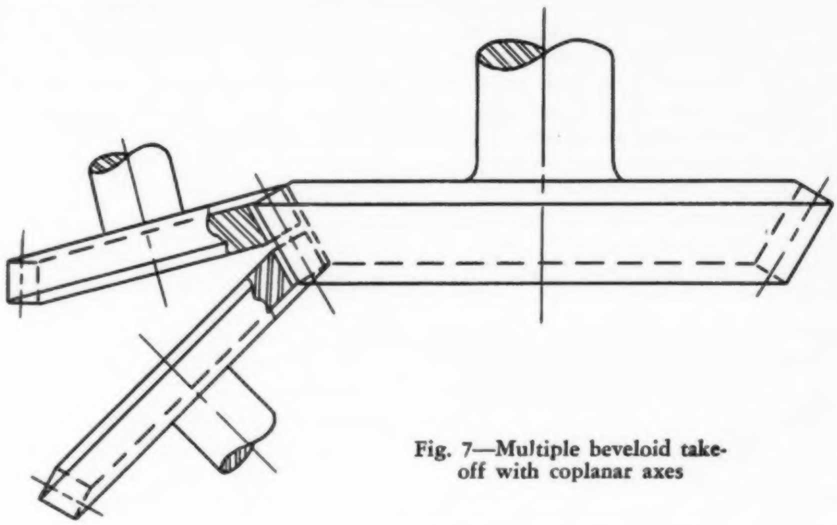
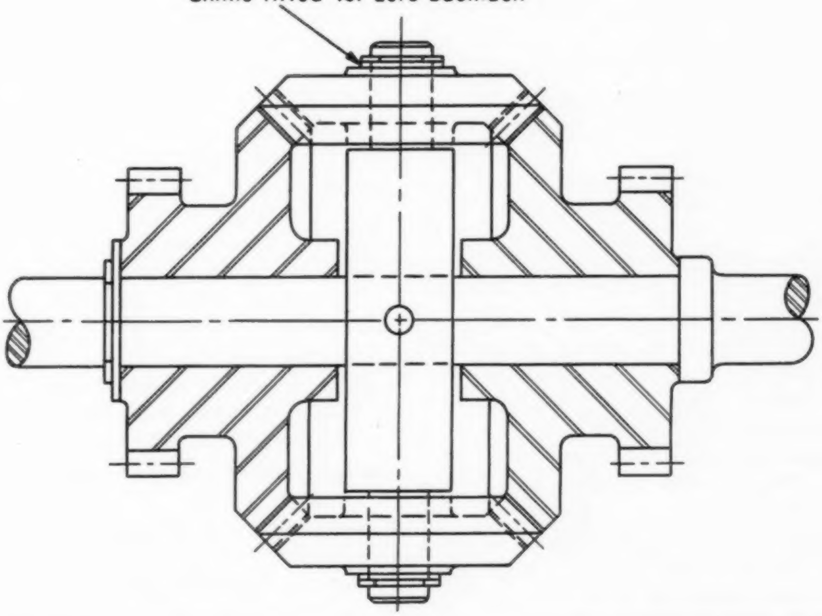


Fig. 7—Multiple beveloid take-off with coplanar axes

Fig. 8—Beveloid differential



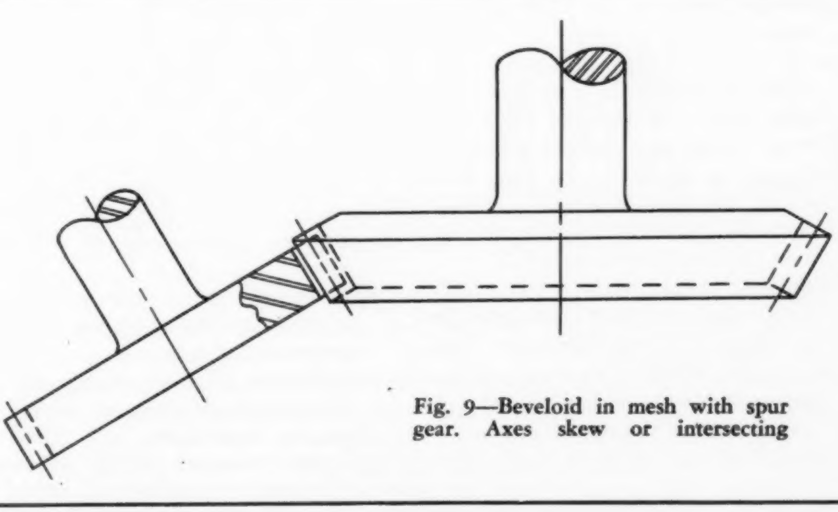


Fig. 9—Beveloid in mesh with spur gear. Axes skew or intersecting

shows the Beveloid gear in mesh with a spur gear. This combination can be used regardless of whether the axes are skew or intersecting. Straight Beveloid gears are used for intersecting axes; oblique Beveloid gears for skew axes. This permits the addition of a gear drive to an existing spur gear train regardless of the required angle or position of the take-off.

Beveloid in Mesh with Helical Gear: This gear combination, *Fig.* 10, also is applicable for skew and intersecting axes. For intersecting axes, the helix of the cylindrical gear requires a corresponding helix in the mating member, which is then an oblique Beveloid gear. For skew or crossed axes, either straight or oblique Beveloid gears could be employed.

Beveloid Gear in Mesh with Worm: This combination, *Fig.* 11, may be used in place of a conventional worm gear drive. It offers the advantage of backlash control through axial adjustment of the tapered Beveloid gear. The Beveloid gear may be straight or oblique. The straight Beveloid gear may be set to the lead angle of the worm, but could also be arranged without lead setting.

Table 1—Beveloid Nomenclature

Kinematic Rolling Cones (*Fig.* 14): Imaginary cones with intersecting axes which, when rolling without slippage, perform the same motion as coaxial bevel or Beveloid gearing.

Rolling Cone Angles (*Fig.* 14): The angle between the axis and the element of a kinematic rolling cone. (Rolling cone angles are determined by the shaft angle Σ and the gear ratio. The design of Beveloid gears is not restricted to these angles.)

Reference Rack: The reference rack of Beveloid gearing consists of the lateral surfaces of an imaginary, straight-sided rack with parallel teeth.

Basic Rack: Reference rack with standard tooth proportions. (It is the basis of the system of interchangeable involute and Beveloid gearing.)

Generating Rack: Reference rack to which the generating tool is conjugate. (The generating rack is usually a basic rack.)

Nominal Plane of Rack (*Fig.* 15): Plane normal to direction of rack teeth.

Pitch Line of Rack: Line in nominal section along which tooth thickness equals space width.

Pitch Plane of Rack (*Fig.* 15): Plane through pitch line perpendicular to nominal plane.

Beveloid Angle (β, B; *Fig.* 15): Angle between gear axis and rack pitch plane. (Shown as angle between pitch and rolling planes.)

Obliquity of Rack (ω, Ω; *Fig.* 15): Angle between direction of rack teeth and normal projection of gear axis on rack pitch plane.

Principal Axial Plane (*Fig.* 15): Axial plane of gear perpendicular to pitch plane of reference rack.

Transverse Plane (*Fig.* 15): Plane perpendicular to pitch plane of rack and principal axial plane.

Rolling Motion of Rack (*Fig.* 15): Translatory component of rack motion perpendicular to principal axial section.

Rolling Cylinder of Beveloid Gear (*Fig.* 15): Cylinder of such diameter that peripheral velocity equals velocity of rolling motion of reference rack.

Pitch Cylinder of Beveloid Gear: Rolling cylinder of specified reference rack.

Rolling Plane of Reference Rack (*Fig.* 15): Plane perpendicular to principal axial plane and tangent to rolling cylinder of Beveloid gear.

Cross Section of Beveloid Gear (*Fig.* 15): Section perpendicular to axis.

Rolling Line of Reference Rack: Intersection of rolling plane of rack and cross section of Beveloid gear.

Standard Section of Beveloid Gear: Cross section where tooth thickness equals space width at rolling diameter.

Helix Angle of Beveloid Gear (ψ): Angle between any helix and an element of its cylinder.

Base Helix Angle (ψ_b): Helix angle at base cylinder.

Helix Angle of Reference Rack (ψ; *Fig.* 15): Angle between the axis of the Beveloid gear and the line of intersection between the rolling plane and the tooth of the rack.

Normal Plane of Reference Rack (*Fig.* 15): Plane normal to line of intersection between the rolling plane and the tooth of the rack.

Center of Action of Beveloid Gears With Intersecting Axes: Point of intersection of rolling planes of reference rack and the common principal axial plane of Beveloid gears.

Symmetrical Rack: Rack with equal nominal pressure angles on opposite tooth sides.

Unsymmetrical Rack: Rack with unequal nominal pressure angles on opposite tooth sides.

Straight Beveloid Gear: Beveloid gear with teeth having symmetrical opposite helices at the rolling cylinder. (Straight Beveloid gears are conjugate to symmetrical racks with zero obliquity.)

Oblique Beveloid Gear: Beveloid gears with teeth having unsymmetrical opposite helices at the rolling cylinder. (Oblique Beveloid gears may have one base cylinder or two base cylinders. They are conjugate to oblique symmetrical or unsymmetrical racks.)

Nominal Linear Pitch (p_o); *Diametral Pitch* (P_o); *Pressure Angle* (ϕ_o): Data referring to nominal plane of reference rack.

Cross-Sectional Linear Pitch (p_c); *Circular Pitch* (p_c); *Diametral Pitch* (P_c); *Pressure Angle* (ϕ_c): Data referring to cross-sectional plane.

Normal Linear Pitch (p_n); *Circular Pitch* (p_n); *Diametral Pitch* (P_n); *Pressure Angle* (ϕ_n): Data referring to normal plane.

Rolling Diameter (D_r); *Radius* (R_r): Diameter and radius of rolling cylinder.

Pitch Diameter (D); *Radius* (R): Diameter and radius of pitch cylinder.

Base Diameter (D_b); *Radius* (R_b): Diameter and radius of base cylinder.

Normal Base Pitch (p_N): Normal distance on developed base cylinder between corresponding base helices of adjacent teeth.

Normal Diametral Base Pitch (P_N): Diametral pitch corresponding to normal base pitch.

Plane of Contact of Beveloid Gear with Reference Rack: Plane tangent to base cylinder and perpendicular to side of reference rack.

Axvolute (*Fig.* 1): Intersection of involute helicoid with axial plane.

Crest Line (*Fig.* 1): Intersection of extended opposite lateral surfaces of teeth. (The crest lines of straight Beveloid gears are axvolutes.)

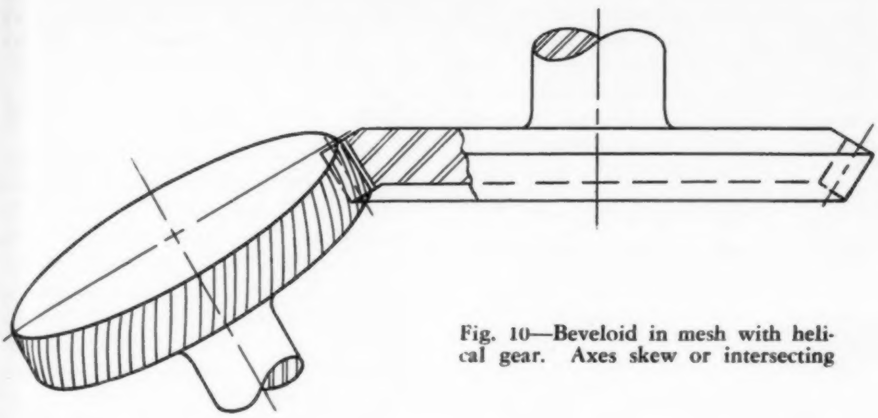


Fig. 10—Beveloid in mesh with helical gear. Axes skew or intersecting

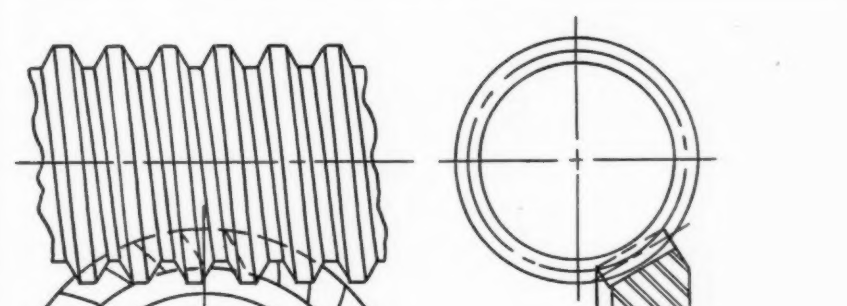


Fig. 11—Beveloid gear in mesh with worm

Beveloid Worm in Mesh with Spur or Helical Gear: The arrangement of *Fig.* 11 is reversed in *Fig.* 12, where the worm is tapered and the gear cylindrical. Backlash adjustment is obtained through an axial shift of the Beveloid worm.

Beveloid Gear in Mesh with Rack: Being an offspring of the basic rack, the Beveloid gear will also operate with a straight-sided rack, *Fig.* 13. In this case, the contact occurs along a line. It will be shown later that the Beveloid gear is not only conjugate to its generating rack, but also to any other rack with the same base pitch.

Beveloid Terminology and Symbols: The study and analysis of Beveloid gearing utilize a number of concepts which require a consistent terminology, *Table* 1. Since even the terms used for conventional gearing are frequently the subject of disagreement, it cannot be claimed that the terminology presented in *Table* 1 is final or complete. The author expects and will appreciate receiving criticism and suggestions in regard to these terms, some of which represent a modification or even a complete change of established gear terminology. If an altogether suitable set of terms is developed, it will be the result of discussion and suggestions. The contribution to the terminology of this subject by Dr. W. F. Vogel of Wayne University is gratefully acknowledged.

Basic Geometry of Straight Beveloid Gear: Beveloid gears are conjugate to generating rack whose pitch plane is inclined against the gear axis. *Fig.* 16 shows the principal axial section of the Beveloid gear, with a transverse section showing the nominal view of the straight generating rack which has the nominal linear pitch p_o and the nominal pressure angle ϕ_o. Standard addendum and dedendum are applied in a direction normal to the pitch line of the generating rack. For the purpose of deriving mathematical relations, the sides of the rack are extended to the sharp point intersections. The height between sharp points is $(p_o/2)\cot\phi_o$. The generating action takes place in cross-sectional planes where the reference rack appears as a rack with a smaller pressure angle. The cross-sectional linear pitch is the same as in view *AA*, but the height between sharp points is increased to $(p_o/2)(\cot\phi_o)/(\cos\beta)$. The cross-sectional pressure angle ϕ_c is determined from the shaded triangle:

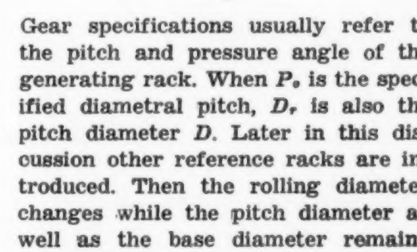
$$\tan\phi_c = \frac{\dfrac{p_o}{2}}{\dfrac{p_o}{2}\,\dfrac{\cot\phi_o}{\cos\beta}} = \tan\phi_o\cos\beta \qquad (1)$$

The rolling diameter of the Beveloid gear is established by:

$$D_r = \frac{N\,p_o}{\pi} = \frac{N}{P_o} \qquad (2)$$

Gear specifications usually refer to the pitch and pressure angle of the generating rack. When P_o is the specified diametral pitch, D_r is also the pitch diameter D. Later in this discussion other reference racks are introduced. Then the rolling diameter changes while the pitch diameter as well as the base diameter remains the same.

Fig. 12—Beveloid worm in mesh with spur or helical gear



The base diameter is found from the familiar relation:

$$D_b = D_r \cos \phi_c \quad (3)$$

Due to the Beveloid angle β, which is the cutting angle, the generating rack is fed into the gear as it advances axially from one cross section to another. If the distance between two cross sections in *Fig.* 16 is x, the infeed of the rack is $x \tan \beta$ which causes the tooth thickness of the rack to decrease on each side by $x \tan \beta \tan \phi_c$. (See black triangle in cross section.) This decrease in tooth thickness is proportional to the axial advance x. Hence, the intersection of the tooth surface with the rolling cylinder is a true helix which appears as a straight line under the helix angle ψ in the developed view of the rolling cylinder. From this view it can be seen that

$$\tan \psi = \tan \phi_o \sin \beta \quad (4)$$

Since the various rack cross sections generate involutes of the same base circle and since a true helix exists at the roling diameter, the tooth surface is an involute helicoid. Helical tooth surfaces can be derived from the tooth surface of a cylindrical spur gear by visualizing this surface as laminated in cross sections, then twisting these sections in accordance with the helix angle ψ. It is seen that the lead is the same at any diameter. The tooth surfaces of the Beveloid gear are geometrically the same as those of cylindrical helical gears, but the helices of opposite sides of the teeth are not parallel. In the case of the straight Beveloid gear, the helices have opposite hands.

Fig. 17 illustrates the relation between the pitch or rolling circumference, the lead and the helix angle, and also the corresponding relation between base circumference, lead and base helix angle. The illustration superimposes the plane development of rolling and base cylinders and demonstrates that

$$\tan \psi_b = \frac{D_b}{D_r} \tan \psi$$

$$= \tan \psi \cos \phi_c \quad (5)$$

Expressing $\cos \phi_c$ in terms of $\tan \phi_c$ and substituting Equations 1 and 4,

$$\sin \psi_b = \sin \phi_o \sin \beta \quad (6)$$

Equations 1, 4 and 6 establish the design parameters ϕ_c, ψ, ψ_b of the Beveloid gear as functions of the given angles ϕ_o and β. The direct relation between ϕ_c, ψ and β is found by elimination of ϕ_o from Equations 1 and 4:

$$\tan \beta = \frac{\tan \psi}{\tan \phi_c} \quad (7)$$

and, in view of Equation 5:

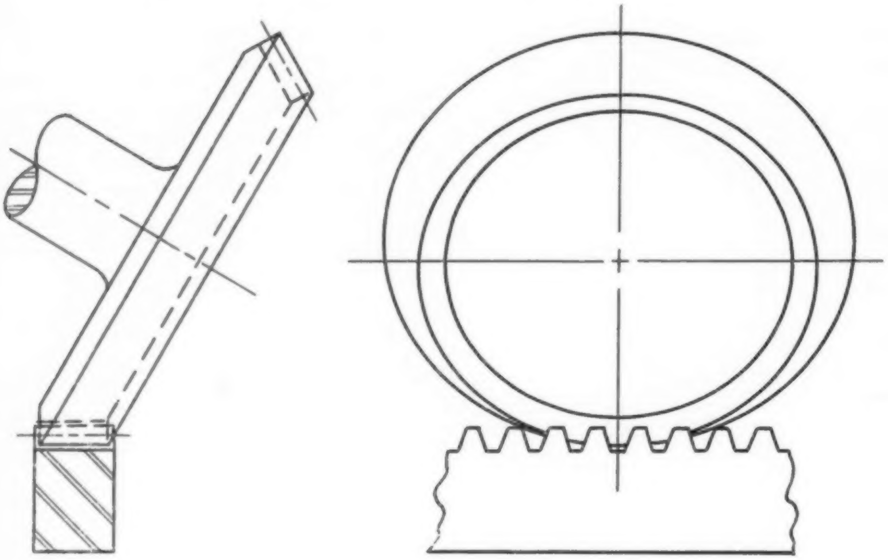
$$\tan \beta = \frac{\tan \psi_b}{\sin \phi_c} \quad (8)$$

In cylindrical helical gearing, the normal pressure angle ϕ_n is frequently used; it is the pressure angle of the normal section. It is determined from $\tan \phi_n = \tan \phi_c \cos \psi$. By expressing $\cos \psi$ in terms of $\tan \psi$ and substituting Equations 1 and 4,

$$\sin \phi_n = \sin \phi_o \cos \beta \quad (9)$$

The normal pressure angle is rarely used for straight Beveloid gears.

Fig. 13—Beveloid gear in mesh with (straight or helical) rack



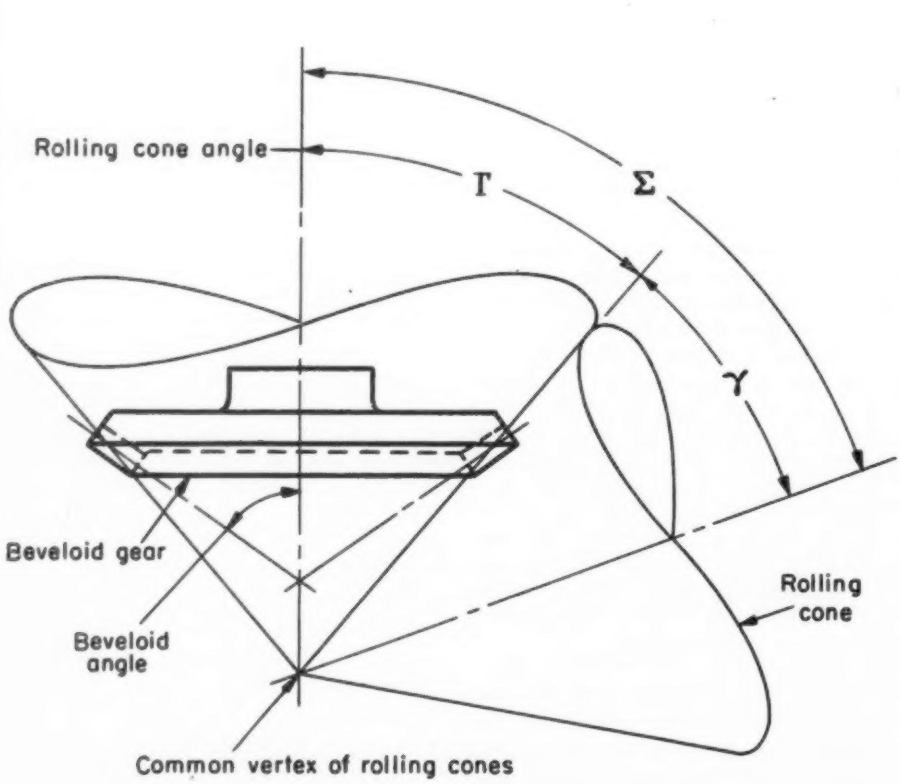


Fig. 14—Independence of rolling cone and Beveloid angles

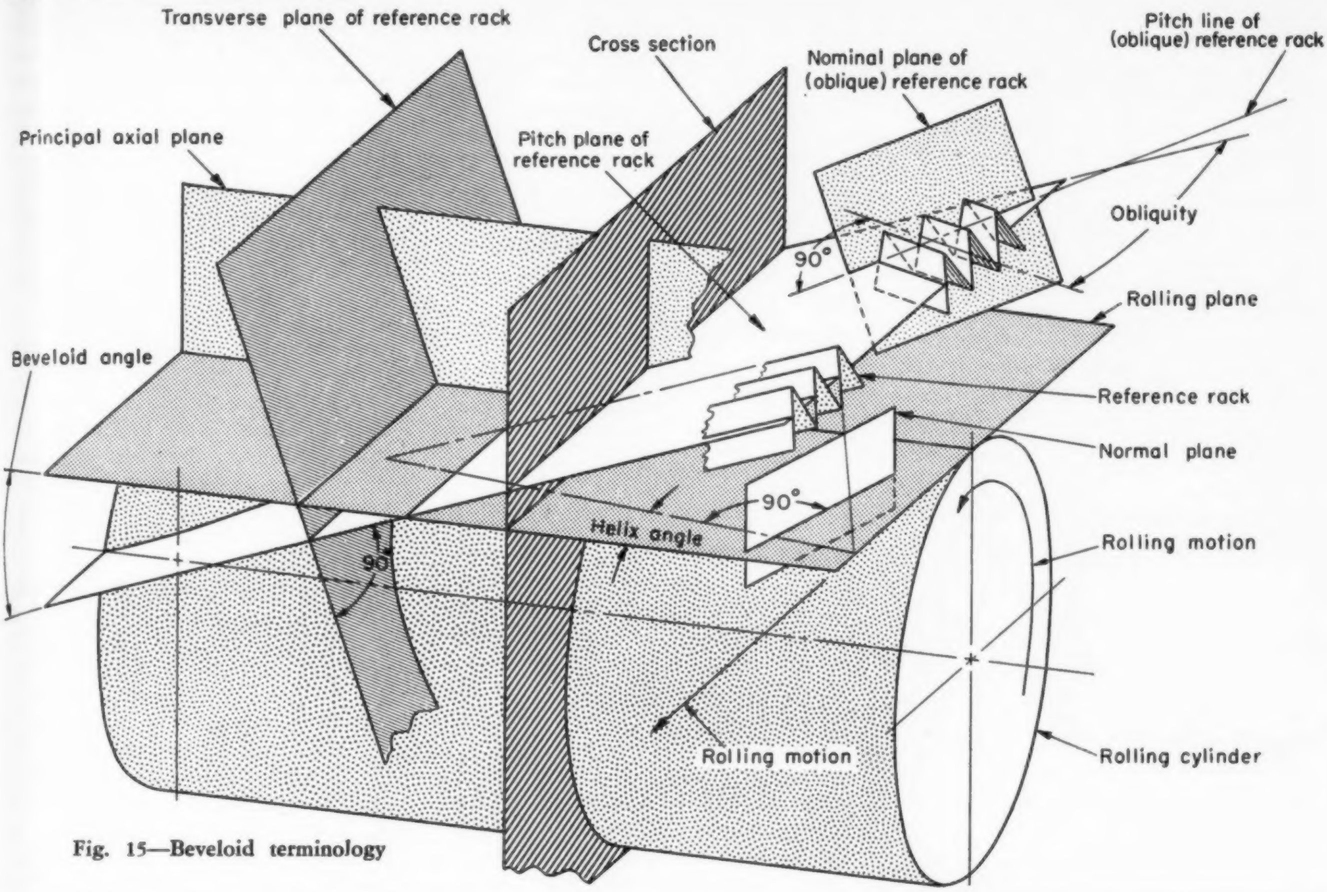
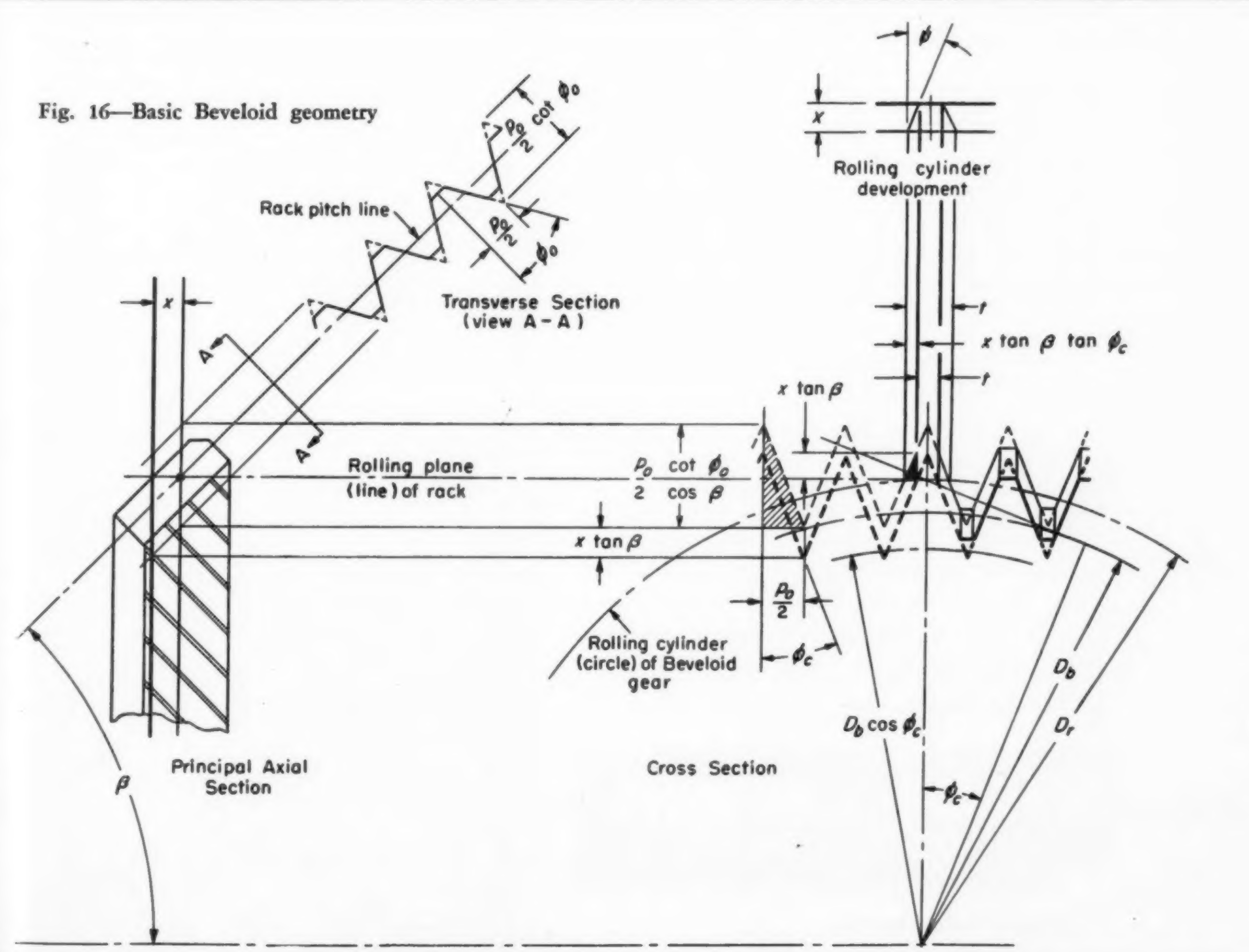


Fig. 15—Beveloid terminology

Fig. 16—Basic Beveloid geometry



BEVELOID GEARING

Line of Contact with Reference Rack: The contact of the reference rack with the involute helicoid tooth surface of the Beveloid gear occurs at the intersection of the plane of contact with the side of the rack. The plane of contact is inclined under the cross-sectional pressure angle ϕ_e against the rolling plane of the rack and goes through the line along which the rolling plane of the rack is tangent to the rolling cylinder of the gear. The plane of contact is, therefore, tangent to the base cylinder. Its projection is shown in *Fig.* 18. Contact points are constructed for two sections.

In the axial distance a between these sections, the rack is transposed vertically by $a \tan \beta$; the relative height of respective contact points is $\tan \beta \sin^2\phi_c$. The inclination of the projection of the contact line in the axial section is, therefore, $\tan \delta = \tan \beta \sin^2\phi_e$. The angle δ is, therefore, always less than β. The angle $\beta-\delta$ is found from:

$$\tan(\beta-\delta) = \frac{\tan\beta\cos^2\phi_e}{1+\tan^2\beta\sin^2\phi_c} = \frac{\tan\beta}{1+\tan^2\phi_c+\tan^2\beta\tan^2\phi_c}$$

and with Equation 1:

$$\tan(\beta-\delta) = \tan\beta\cos^2\phi_o$$

Since the angle between the rack surface and the axial section of *Fig.* 18 is the nominal rack pressure angle ϕ_o, the angle $\beta-\delta$ is the projection of an angle κ on the rack surface which is defined by

$$\tan\kappa = \tan\beta\cos\phi_o \qquad (10)$$

Path of Contact of Beveloid Gears with Coplanar Axes: Since each Beveloid gear contacts the common reference rack along a line which includes an angle with the gear axis smaller than the Beveloid angle, the contact between the two Beveloid gears will occur at the intersection of these two nonparallel contact lines on the rack surface. As the gears rotate, the contact point moves along a path of contact which is the intersection of the planes of contact of the two Beveloid gears. The projections of these planes of contact are shown in *Fig.* 19 in cross sections of gears 1 and 2; they are projections of the common path of contact. Point C_a is the intersection of the elements of both rolling cylinders which lie in the common principal axial section of the gears.

If an auxiliary plane *BB* is laid at the distance d from the common axial plane *AA*, the path of contact intersects this plane in a point D which can be projected into the axial view. Perpendiculars drawn in the axial view from point C_a to the projection lines lead to the shaded quadrilateral; its diagonal C_aD is the axial projection of the path of contact. The angle of the quadrilateral at the point C_a is equal to the sum of the Beveloid angles $\beta_1 + \beta_2$. The diagonal C_aD divides this angle into two angles ϵ_1 and ϵ_2. Two sides of the quadrilateral are known from the cross-sectional views as $d \tan\phi_{c1}$ and $d \tan \phi_{c2}$. The length of the diagonal can be expressed in terms of these two sides as

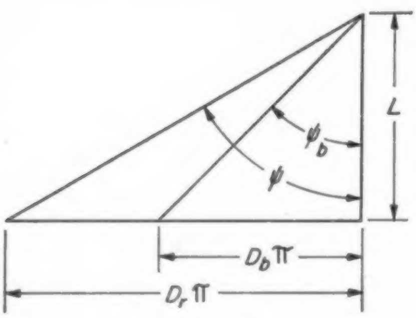


Fig. 17—Development of base and rolling cylinders

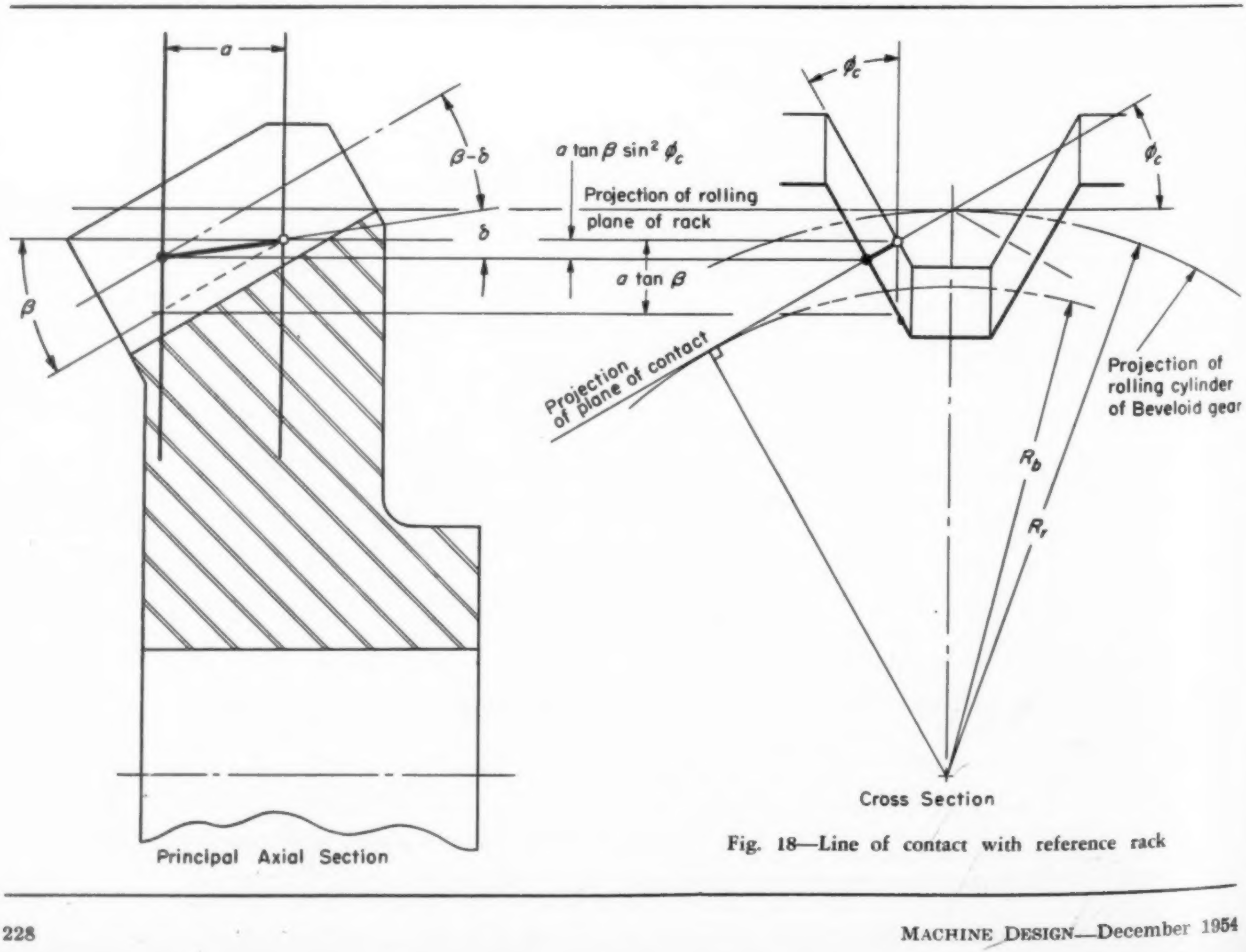


Fig. 18—Line of contact with reference rack

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$$\frac{d \tan \phi_{c1}}{\cos \varepsilon_1} = \frac{d \tan \phi_{c2}}{\cos \varepsilon_2}$$

which, with Equation 1, becomes

$$\frac{\cos \varepsilon_1}{\cos \varepsilon_2} = \frac{\cos \beta_1}{\cos \beta_2}$$

Since $\varepsilon_1 + \varepsilon_2 = \beta_1 + \beta_2$, the angles ε_1 and ε_2 must be equal to β_1 and β_2, respectively. Hence, the path of contact in the axial view is perpendicular to the projection of the pitch plane of the reference rack. The relations shown in the nominal view of the rack, which are based on Equation 1, further show that the path of contact is perpendicular to the side of the rack. The point C_a is designated as center of action. It is a point of the instant axis of relative motion where the relative velocity of the gears is zero. The instant axis passes through the intersection of the gear axes (common vertex) and is a common element of the kinematic rolling cones (not shown in *Fig.* 19). The center of action of Beveloid gears with coplanar axes is a point of their path of contact.

Path of Contact of Beveloid Gears with Offset Axes: The contact of each Beveloid gear with the common reference rack still takes place in the plane of contact of each gear which is tangent to the base cylinder and includes the cross-sectional pressure angle with the rolling plane of the rack. The direction of these planes of contact is the same as for coplanar axes although their relative position is shifted in the direction of the offset. The path of contact which is the intersection of the planes of contact remains, therefore, perpendicular to the side of the common reference rack.

Fig. 20 shows the relative position of two Beveloid gears, illustrated as cones. The offset o is seen in the cross-sectional views of gears 1 and 2. AA and BB represent the principal axial planes of gears 1 and 2 respectively. Gear 1, which may be assumed to be the driver, is shown in bold lines, gear 2 in light lines. Projections of the planes of contact are shown in corresponding solid lines for the drive sides of the teeth, dotted lines for the trailing sides.

To find the point of intersection of the solid line, planes of contact in the auxiliary plane AA, lines of intersection of each plane of contact with the auxiliary plane are first determined. These lines of intersection project as points in the cross sections of the two gears. In the axial view, they

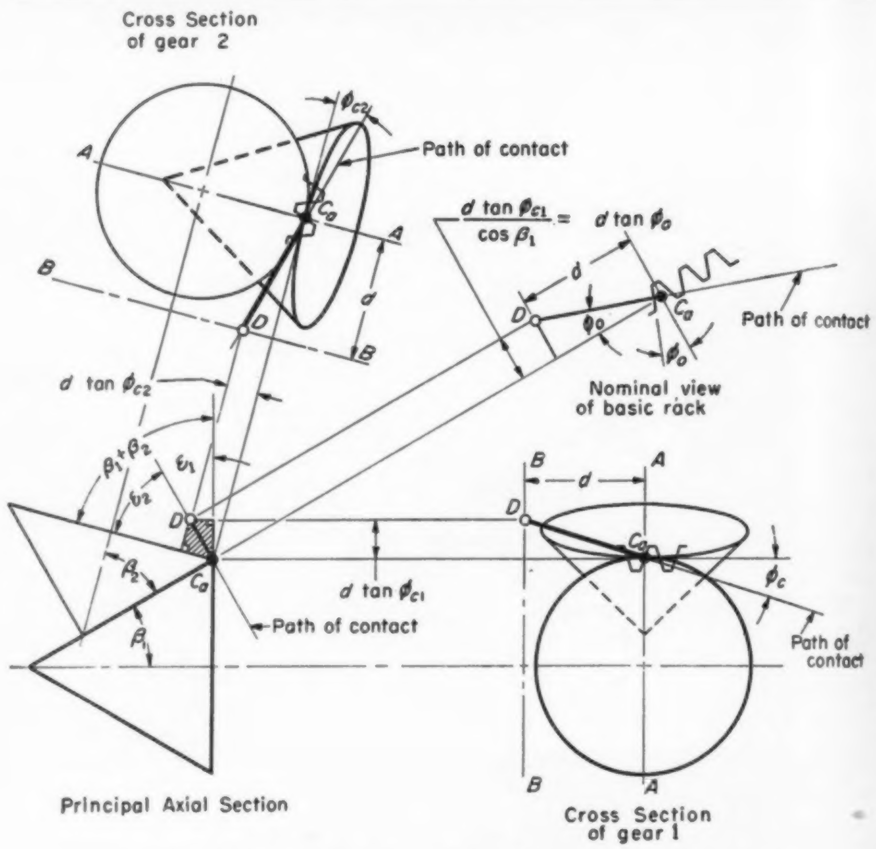
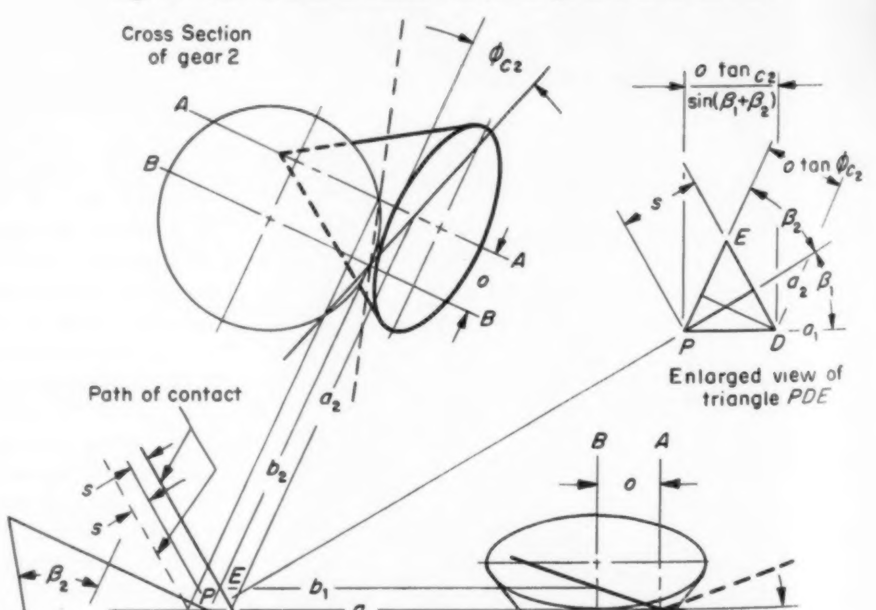


Fig. 19—Path of contact between Beveloid gears with coplanar axes

Fig. 20—Path of contact between Beveloid gears with offset axes



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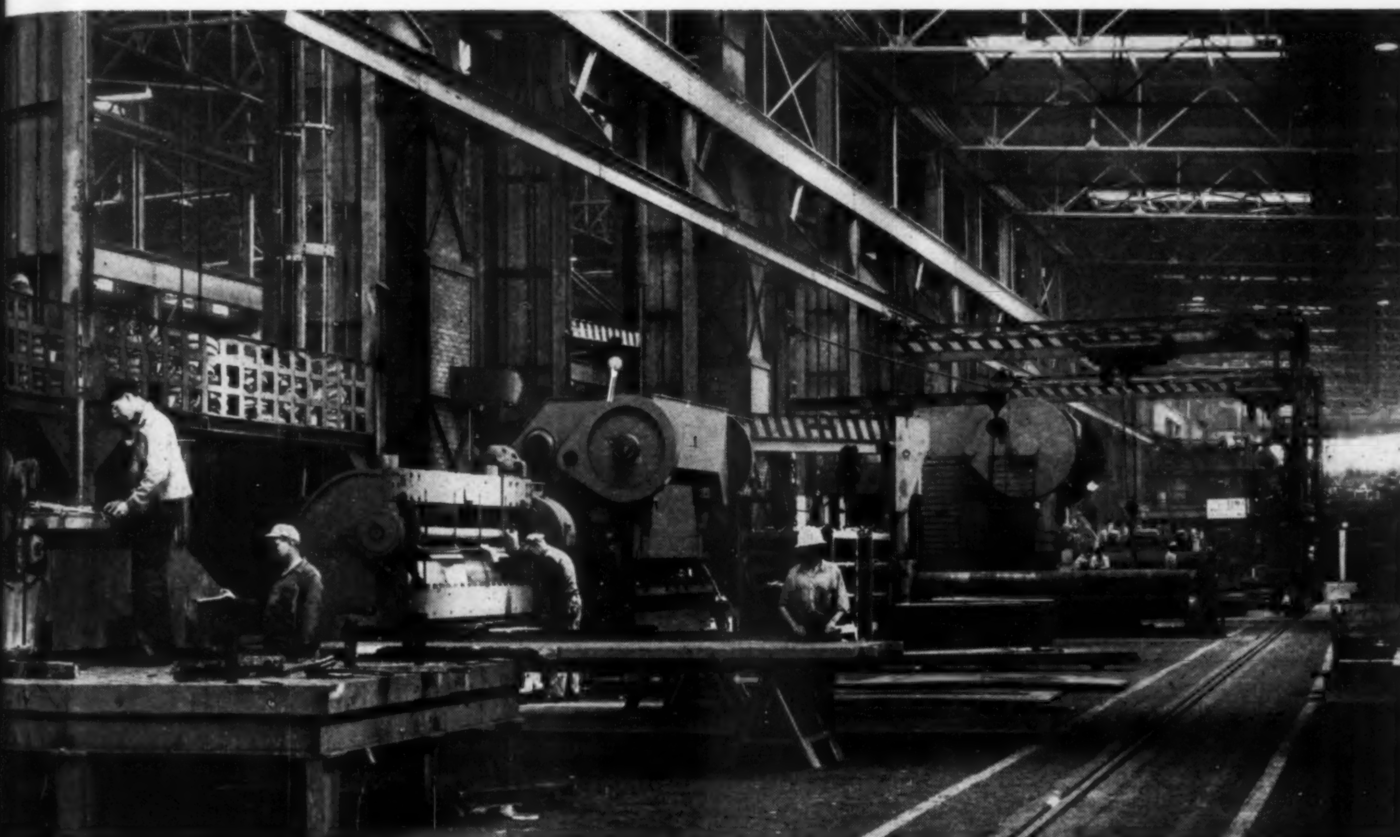

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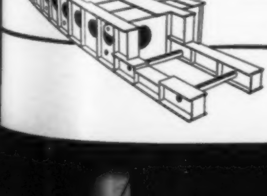

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are represented by lines a_1 and a_2 which intersect at point D. The corresponding construction, utilizing the auxiliary plane BB and intersection lines b_1, b_2, leads to point E. The extension of ED is the axial view of the path of contact.

A similar construction, made for the trailing sides of the teeth, leads to the dotted path of contact in the axial view, which is symmetrical to the full line path of contact with respect to point P.

Due to the offset, both paths of contact are shifted in the direction of the rack teeth. The magnitude of shift $\pm s$ is determined from the enlarged view of the triangle PDE. Since PD and PE are parallel respectively to the axes of gears 1 and 2, the altitude from point P divides the angle DPE into angles β_1 and β_2. The altitude from point D has the length $o \tan \phi_{c2}$. The shift s of the paths of contact is found from

$$s = (PD) \cos \beta_1 = \frac{o \tan \phi_{c2} \cos \beta_1}{\sin (\beta_1 + \beta_2)}$$

which, with Equation 1, becomes

$$s = \frac{o \tan \phi_o}{\tan \beta_1 + \tan \beta_2} \quad (11)$$

This analysis shows that Beveloid gears designed for intersecting axes will operate just as well with offset axes. The changed relation between the gear axes may be either intentional or the result of mounting errors. Similar offsetting with other types of bevel gearing requires gear redesign.

Family of Reference Racks: A property of the involute helicoid is that an infinite number of mating racks can be constructed in addition to the original generating rack. Each of these reference racks is operating at another rolling diameter which, therefore, may be assumed as D_r'. The transverse pressure angle at any assumed diameter D_r' is determined from $\cos \phi_c' = D_b/D_r'$. The helix angle at the assumed diameter is readily found from Equation 5:

$$\tan \psi' = \frac{\tan \psi \cos \phi_c}{\cos \phi_c'}$$

The nominal linear pitch of the new reference rack is equal to the cross-sectional circular pitch at the selected diameter:

$$p_o' = \frac{p_b}{\cos \phi_c'} = p_o \frac{\cos \phi_c}{\cos \phi_c'} \quad (12)$$

The cross-sectional pressure angle and helix angle at the diameter D_r' define the directions of both lateral surfaces of the rack, the intersection of which is a line under a new Beveloid angle β', which is defined by Equation 8. The nominal pressure angle of the new reference rack is found from Equations 1 and 8 as follows:

$$\tan \phi_o' = \frac{\tan \phi_c'}{\cos \beta'}$$

$$= \tan \phi_c' \sqrt{1 + \frac{\tan^2 \psi_b}{\sin^2 \phi_c'}}$$

$$= \frac{\sqrt{\sin^2 \phi_c' + \tan^2 \psi_b}}{\cos \phi_c'} \quad (13a)$$

$$\cos \phi_o' = \cos \psi_b \cos \phi_c' \quad (13b)$$

If two mating Beveloids are assumed, each designed from a given common generating rack, new reference racks can be designed for each Beveloid gear. In view of Equations 12 and 13, these new reference racks will be common for both gears, if the ratio $\cos \phi_c/\cos \phi_c'$ is the same, because both new racks will have the same pitch p_o' and the same nominal pressure angle ϕ_o'. Both Beveloid gears can, therefore, be brought into engagement by matching the new reference racks. Since the Beveloid angles have changed, a new shaft angle will exist, equal to the sum of the new Beveloid angles β_1' and β_2' obtained from Equation 8.

On the other hand, if a new shaft angle Σ is given, the corresponding Beveloid angles can be found from Equation 6, as follows:

$$\frac{\sin \psi_{b1}}{\sin \psi_{b2}} = \frac{\sin \beta_1}{\sin \beta_2} = \frac{\sin \beta_1}{\sin (\Sigma - \beta_1)}$$

$$= \frac{1}{\sin \Sigma \cot \beta_1 - \cos \Sigma}$$

from which

$$\cot \beta_1 = \frac{\dfrac{\sin \psi_{b2}}{\sin \psi_{b1}} + \cos \Sigma}{\sin \Sigma} \quad (14)$$

Of course, $\beta_2 = \Sigma - \beta_1$.

For a given set of Beveloid gears, a set of Beveloid angles can be established for any assumed shaft angle Σ by using Equation 14 in which $\sin \psi_{b_1}$ and $\sin \psi_{b_2}$ would be constants.

The practical significance of these geometrical relations is that shaft angles can be changed without affecting the conjugate action of Beveloid gears. Errors in the angular location of mating Beveloid gears have no effect on their operation as long as the position of the path of contact remains on the involute helicoid surfaces and the clearance between tips and roots of mating gears is not absorbed by the change in relative position. Conventional bevel gears require that their shaft angle be equal to the sum of their constant pitch cone angles.

Equation 13 also permits the following development (see also Equation 1):

$$\cos \psi_b \sin \phi_c = \cos \phi_o \tan \phi_c$$

$$= \sin \phi_o \cos \beta \quad (15)$$

Variable Relative Location of Beveloid Gears: *Fig.* 21 shows an axial view of two Beveloid gears with coplanar axes. The path of contact goes through the center of action.

In the left-hand view the gears are positioned so that the center of action lies in the standard sections of both gears. This position may be designated as a standard mesh position since both gears have standard tooth thickness at the intersection of their rolling planes in the common axial plane.

If a phantom reference rack is assumed between the gear teeth, each gear has line contact with this rack and maintains this contact when it slides parallel to the direction of the rack. Involute contact will, therefore, be maintained between the gears. The result of such sliding is shown in the right-hand view. The path of contact still goes through the intersection of the rolling lines, but the center of action has moved toward the front face of the horizontal-axis gear, toward the back face of the inclined-axis gear. A thin tooth of the horizontal-axis gear meshes with a thick tooth of the inclined-axis gear.

When undercut occurs it is, of course, prevalent near the front face. The shift in the direction of the common rack may be used to increase the distance of the path of contact from the undercut area of one Beveloid gear. The corresponding distance in the mating Beveloid gear would be decreased. The blank design should be adjusted, after the shift, to maintain a central position of the contact area on the gear face.

The shift or translation maintains constant or zero backlash. In addition, translation is possible in any other direction within the common axial plane if constant or zero backlash need not be maintained. A shift perpendicular to the axial plane, or offset, is also possible, as was demonstrated in the discussion of the path of contact. Hence, one gear can be adjusted with respect to the other, in any direction, without affecting the accuracy of conjugate action.

The possible change of shaft angles, discussed under *Family of Reference Racks,* shows that it is also possible to perform relative rotation of the gears about an axis perpendicular to

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the plane of *Fig.* 21. Any rotation about an axis within this drawing plane can be resolved into component rotations about the two gear axes and is, therefore, an original function of the gear design. It is concluded, therefore, that mating Beveloid gears may be brought into any relative position as long as there is no physical interference of the gear blanks and the path of contact maintains a sufficient length.

Variability of Standard-Mesh Positions: After each change of shaft angle, the considerations of *Fig.* 21 could be repeated and an infinite number of possible relative positions be established, one of which would be the standard mesh position for the new shaft angle. All points on one gear which are centers of action in the standard mesh position with any mating Beveloid gear can be defined by the condition that tooth thickness equals space width or that the tooth semiangle is $\pi/2N$. The locus of all these points is, therefore, the intersection of the involute helicoid with an axial plane which is inclined against the plane of symmetry of the tooth under the angle $\pi/2N$. The curve thus defined is an axvolute and is shown in *Fig.* 22.

A co-ordinate system is assumed whose X-axis is the gear axis while the Y-axis is laid through the origin of the axvolute at the base circle. The co-ordinates of this point are $(0, R_b)$. A point of the axvolute with abscissa x has the radial distance

$$y = R_x = \frac{R_b}{\cos \phi_{cx}} \qquad (16)$$

where ϕ_{cx} is the cross-sectional pressure angle at the arbitrary radius R_x. The distance x is found from the known angular twist of the base helix which starts at the origin of the axvolute. An involute (dashed curve) is laid through the origin of the axvolute. The angle of rotation between the dashed involute profiles is inv ϕ_{cx}. The corresponding arc at the base circle is R_b inv ϕ_{cx}. According to the development of the base helix shown in *Fig.* 22, this arc is also equal to $x \tan \psi_b$ so that

$$x = \frac{R_b \operatorname{inv} \phi_{cx}}{\tan \psi_b} \qquad (17)$$

Equations 16 and 17 give the co-ordinates of the axvolute as convenient functions of the parameter ϕ_{cx}. The slope of the axvolute is found from the following derivation which utilizes Equation 8:

$$\frac{dy}{d\,\phi_{cx}} = \frac{R_b \sin \phi_{cx}}{\cos^2 \phi_{cx}} = \frac{R_b \tan^2 \phi_{cx} \tan \beta_x}{\tan \psi_b} \qquad (18)$$

$$\frac{dx}{d\,\phi_{cx}} = \frac{R_b \tan^2 \phi_{cx}}{\tan \psi_b} \qquad (19)$$

$$\frac{dy}{dx} = \tan \beta_x \qquad (20)$$

In view of Equation 8, the slope of the axvolute becomes infinite at the origin $((0, R_b))$ and the Y-axis is a tangent of the axvolute. The slope of the axvolute, for any given point, can be considered as that of a reference rack with nominal pressure angle ϕ_o which can be determined from Equation 6. Corresponding points of the axvolutes of mating Beveloid gears are points with equal nominal pressure angle ϕ_o.

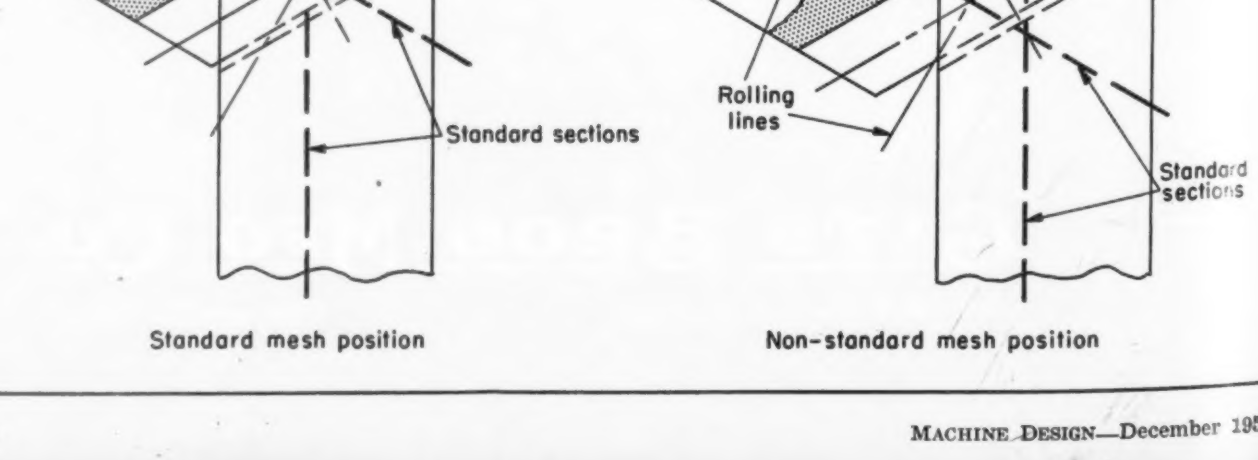
All standard mesh positions of two mating Beveloid gears can be obtained by matching corresponding points of their axvolutes so that the axvolutes are tangent to each other. In each standard mesh position, it is further possible to slide one Beveloid gear against the other along their common reference rack, or along the tangents of the axvolutes, and maintain zero backlash and conjugate action. In addition, any other translation is permissible if zero backlash need not be maintained.

The length of the axvolute is found by utilizing Equations 1, 13, 15, 18 and 19 (replacing ϕ_{cx} by ϕ_c), and also the relation between $d\phi_o$ and $d\phi_c$ found by differentiation of Equation 13:

$$\sin \phi_o \, d\,\phi_o = \cos \psi_b \sin \phi_c \, d\,\phi_c$$

$$ds = \sqrt{dx^2 + dy^2} = \frac{R_b \tan^2 \phi_c}{\tan \psi_b} \sqrt{1 + \tan^2 \beta}\, d\phi_c = \frac{R_b \tan^2 \phi_o}{\tan \psi_b} d\,\phi_o$$

Fig. 21—Change of mesh position (constant shaft angle)



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$$s = \frac{R_b}{\tan \psi_b} (\text{inv}\, \phi_{o2} - \text{inv}\, \phi_{o1}) \qquad (21)$$

The nominal pressure angles ϕ_{o_1} and ϕ_{o_2} of two mating gears are always the same so that the corresponding lengths of two axvolutes will be equal, if the value $R_b/\tan \psi_b$ is the same for both gears. According to *Fig.* 17 and Equation 4,

$$\frac{R_b}{\tan \psi_b} = \frac{R}{\tan \psi} = \frac{R}{\tan \phi_o \sin \beta}$$

This quantity will be equal on both gears if the "cone distance" $R/\sin \beta$ is the same or when the rack pitch plane goes through the intersection of the gear axes. In this case the lead will also be the same because $R_b/\tan \psi_b = L/2\pi$. It can be stated, therefore, that the gears can roll on the axvolutes without slippage and maintain standard mesh positions if they have equal lead, or if the pitch plane of the rack is tangent to the kinematic rolling cones.

The radius of curvature ρ of the axvolute is found from Equations 1, 19 and 20:

$$y'' = \frac{dy'}{d\phi_c} \; \frac{d\phi_c}{dx}$$

$$= - \frac{\tan \psi_b \cos \phi_c}{\sin^2 \phi_c} \; \frac{\tan \psi_b}{R_b \tan^2 \phi_c}$$

$$= - \frac{\tan^2 \beta \cos \phi_c}{R_b \tan^2 \phi_c}$$

$$\rho = \frac{[\sqrt{1 + (y')^2}\,]^3}{y''}$$

$$= \frac{R_b \tan^2 \phi_c}{\cos^3 \beta \tan^2 \beta \cos \phi_c}$$

$$= \frac{R_b \tan^3 \phi_o}{\tan \beta \tan \psi_b} \qquad (22)$$

where the negative sign is disregarded. In many cases a circle with this radius can be substituted for the axvolute and the relative motion of the gears can be approximated by two simple rotations.

A set of straight Beveloid miter gears with 48 teeth, 24 nominal diametral pitch, 20-degree nominal pressure angle and 45-degree Beveloid angle, which was designed by the author for a machine tool application requiring ±5-degree shaft angle variation, permitted a change of shaft angle by +10 and −20 degrees, or a total range of 30 degrees. This design arrangement did not permit hinging at the centers of curvature; yet, the backlash variation was less than 0.00015-inch for ±5-degree swing, 0.0005-inch for 10-degree shaft angle increase, 0.002 for 20-degree decrease.

When the Beveloid gears do not have the same lead, sliding along the axvolutes will be necessary to match consecutive sets of corresponding axvolute points. As each Beveloid gear swings about the center of curvature of corresponding axvolute points, the velocity of the swinging motion will be the same at distances ρ_1' and ρ_2' from the respective centers of curvature. These adjusted radii are determined from

$$\rho_1' \, d\alpha_1 = \rho_2' \, d\alpha_2$$

where $d\alpha_1$ and $d\alpha_2$ represent increments of angular motion equal to ds_1/ρ_1 and ds_2/ρ_2 respectively. Hence

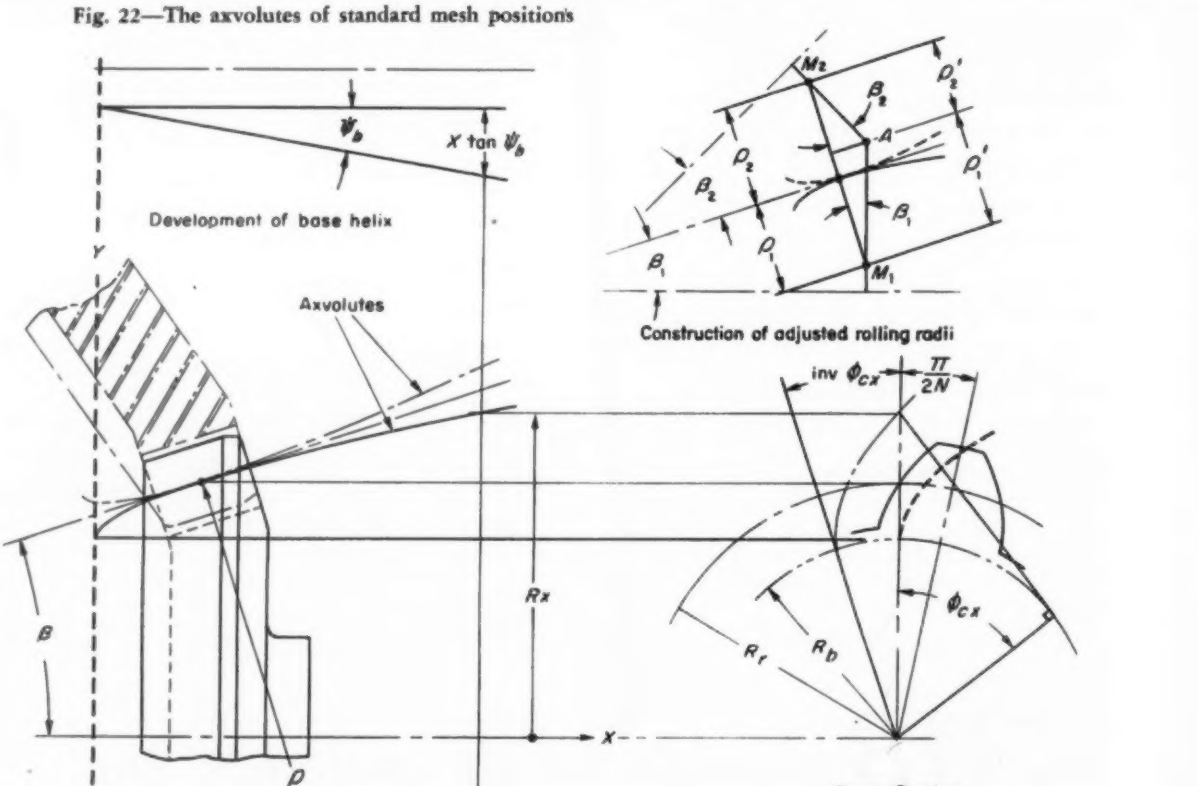
$$\rho_1' \, \frac{ds_1}{\rho_1} = \rho_2' \, \frac{ds_2}{\rho_2}$$

In view of the developments of Equations 21 and 22, this identity can be transformed to

$$\rho_1' \, \frac{\tan \beta_1}{\tan \phi_o} \, d\,\phi_o = \rho_2' \, \frac{\tan \beta_2}{\tan \phi_o} \, d\,\phi_o$$

$$\rho_1' = \rho_2' \, \frac{\tan \beta_2}{\tan \beta_1}$$

Fig. 22—The axvolutes of standard mesh positions



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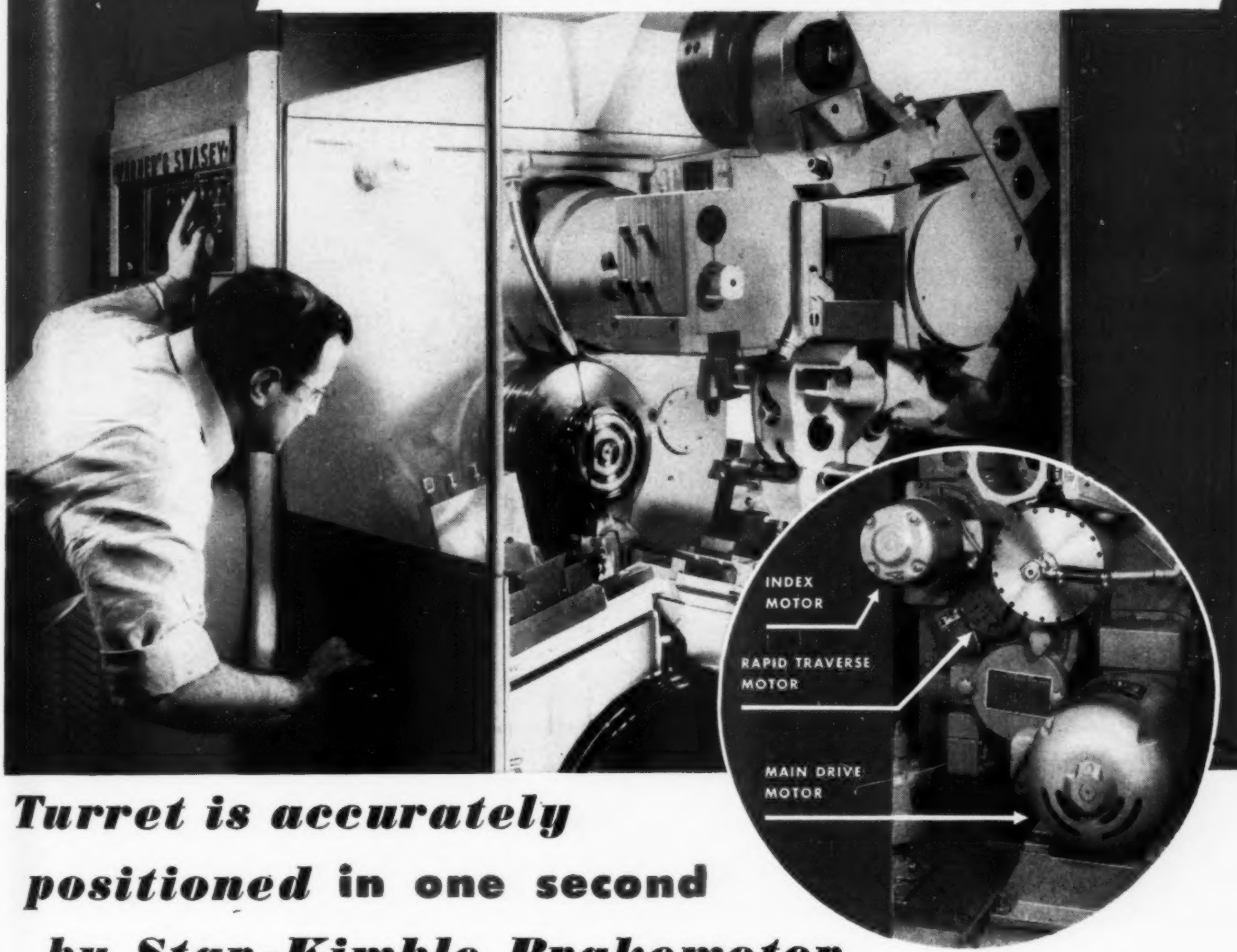

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Since $\rho_1' + \rho_2' = \rho_1 + \rho_2$, the adjusted radii ρ_1' and ρ_2' can be found from the construction shown in the upper right-hand corner of *Fig.* 22.

Perpendiculars are drawn through the centers of curvature M_1 and M_2 to the respective gear axes. Point A is the intersection of these perpendiculars. A line through point A, normal to line M_1M_2 divides the latter distance into ρ_1' and ρ_2'.

Since the axvolute is partly inside and partly outside its circle of curvature, substitution of circles causes looseness for a shaft angle increase, binding for a shaft angle reduction. The amount of these deviations can be found by determining the distances between axvolutes and circles of curvature within the required range of swing motion. Interference in the assembly is averted simply by relative gear adjustment on the axes in the tightest mesh position with minimum shaft angle. Thus, the gears can be hinged with respect to each other and uniform motion be obtained within the range of predetermined variation.

Length of Path of Contact: Solution of this problem is required to determine the contact ratio which is the length of the path of contact divided by the normal base pitch: $p_N = p_o \cos \phi_o$.

The terminal points of the path of contact are the intersections of this straight line with the outside cones. This problem could be treated in an exact analytical or geometrical manner, both of which are rather cumbersome and inconvenient. The use of Tredgold's approximation, as shown for coplanar axes in the left-hand view of *Fig.* 23 is, therefore, recommended. An auxiliary plane LL, through the path of contact and perpendicular to the common principal axial plane, intersects the outside cones along ellipses. Considering only the light-lined gear, the curvature at the elliptical vertex A has its center at the intersection of the auxiliary plane LL with the gear axis. In the transverse view, the ellipse is approximated by the circle having the same curvature, and the path of contact can be seen in its true projection. The addendum circles in the transverse view intersect the path of contact in the two terminal points of gear contact. The length of the path of contact can then be determined either graphically or through computation.

The same type of construction is shown in the right-hand illustration of *Fig.* 23 for gears with offset axes. In this case, each circle is offset in the transverse view with respect to the intersection of the path of contact with the rack pitch plane. With Equations 1 and 11, the amount of offset is

$$o_1 = \frac{s \sin \beta_1}{\tan \phi_{c1}} = \frac{o \tan \beta_1}{\tan \beta_1 + \tan \beta_2} \quad (23a)$$

$$o_2 = o - o_1 \quad (23b)$$

Separate transverse views are required for each path of contact with different radii of curvature.

Details on the practical design of Beveloid gears will be published in future issues of MACHINE DESIGN.

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2. W. F. Vogel—*Involutometry and Trigonometry*, Michigan Tool Co., 1945.

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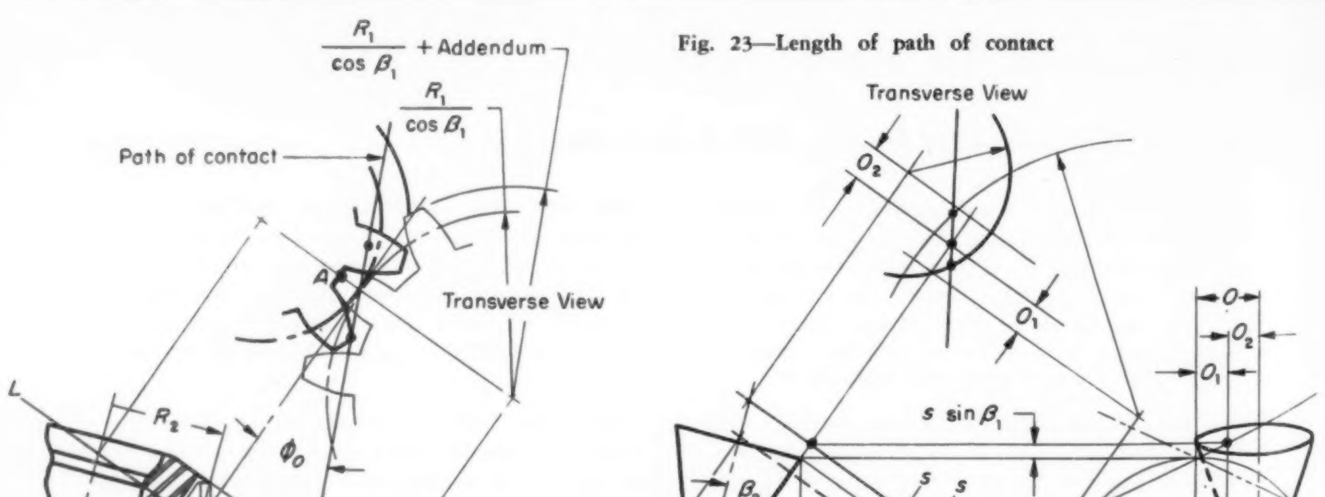
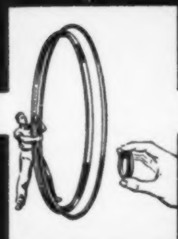


Fig. 23—Length of path of contact



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Helpful Literature

(Continued from Page 242)

engines and gas turbines, turbo-super chargers, rockets and guided missiles. They also have wide possibilities in steam turbines, oil refineries and other equipment.

37. Two-Cycle Diesel Engines

Harnischfeger Corp., Diesel Div.—Twenty design features are listed and keyed to a cutaway drawing of a series C-18 two-cycle diesel engine in 16-page illustrated bulletin Z-15. Models with 2, 3, 4 and 6 cylinders have their specifications and performance curves given. Enclosed, general, marine, skid-mounted, power take-off and torque converter equipped models are available.

38. Molded Silicone Rubber Parts

Minnesota Rubber & Gasket Co.—Injection molding of silicone rubber products is subject of illustrated bulletin. Properties and applications of silicone rubber to specific types of parts and service are tabulated.

39. Plug-Mounted Relays

Automatic Electric Sales Corp.—Detailed descriptions of a complete line of industrial relays, plug-mounted for advantages in assembly, inspection, service and maintenance, are contained in illustrated circulars 1801-1805.

40. Reamer Price Catalog

Lavallee & Ide, Inc.—20-page catalog 100 entitled "Comparative Net Price Selector" features unique arrangement of line of reamers by decimal equivalents from 0.0400 to 3.0000 in. Every reamer is illustrated and described by type, shank, flute, length, L & I list number and price. Also covered are reamer sets, reamer blanks, blank sets and special reamers.

41. Surface Roughness Scale

Baptist Machine Co.—The S22 microfinish comparator provides established flat-surface roughness specimens for visual and factual comparison. Scale is used in specifying and controlling surface roughness when a product having the appearance of typically machined surfaces is required. 4-page bulletin describes it further.

42. Industrial Engine

Ford Motor Co.—Complete description of the Ford 172 four-cylinder industrial engine is provided in 8-page form IE 7511. This overhead valve gasoline engine has 3.90 x 3.60 bore and stroke, a compression ratio of 6.75:1 and is rated 24.4 hp A.M.A. Features are pointed up and accessories are described.

43. Toggle Clamps

Detroit Co.—De-Sta-Co toggle clamps described and illustrated in 16-page catalog 52-A are offered in more than 40 sizes and types. Clamps feature fast clamping, positive holding and instantaneous release of workpieces. Styles cover horizontal clamps from 375 lb holding capacity, portable plier clamps and heavy duty plunger types with up to 4000 lb capacity.

44. Conveyor Units & Systems

W. F. & John Barnes Co.—How 27 materials handling problems were solved with Barnes mechanized units is pictured and described in folder-type brochure on "Practical-Engineered Conveyor Units and Systems." Each, an automation unit in itself, is individually designed from standard components to meet needs of the particular job.

45. Silicone Rubber Parts

Acushnet Process Co.—Supplement B to Acushnet Rubber Data Handbook provides 8 pages of information about silicone precision-molded rubber parts. It covers O-rings, gaskets, boots, insulators, bonded parts and miscellaneous items. Rubber can withstand temperature extremes from −140 to 600° F. Unusual applications of silicone rubber are pictured.

46. Hydraulic Drives

Oliver Iron & Steel Corp., Berry Div.—Berry Hydraulic Drives for sawmill carriages are detailed in 8-page bulletin. Drives are available as complete packaged units, including pump, motor, cooler and other components. Feature of bulletin is drive selector which gives proper drive, number for various carriage weights, strokes and lines per minute.

47. Iron Powder Product

National Radiator Co., Plastic Metals Div., —Technical data sheets PMS 28A and 28B give chemical and physical characteristics of Plast-Iron B-212, a reduced-oxide iron powder. Product is intended for compacting parts requiring high tensile or transverse strength. Table lists properties of sintered specimens containing various percentages of copper.

48. Plain & Self-Locking Nuts

National Machine Products Co.—Just how the new Twelve Pointer plain and self-locking nuts permit use with small tool clearances is explained in 12-page illustrated bulletin "Something New in Nuts." Design distributes the wrench load so that thin-wall double hex socket wrenches can be used.

49. Push-Pull Controls

Arens Controls, Inc.—32-page illustrated design manual "A Guide to the Selection and Application of Arens Push-Pull Controls" shows available styles of flexible and rigid push-pull controls as well as knob-plunger, lever, detent and locking type head assemblies. Complete data are given to aid in applying these units to machines and equipment.

50. Time Delay Relays

A. W. Haydon Co.—Hermetically-sealed adjustable time delay relays described in bulletin TD401 are offered in delay periods from 2 seconds to 2 hours. Units meet military specs and can be supplied for operation on direct or alternating current power. Relay consists of standard adjustable unit coupled to hermetic rotary seal.

51. Electric Switches & Assemblies

Minneapolis-Honeywell Regulator Co., Micro-Switch Div.—Illustrated data sheets 80, 14PA1, P87, P79, P86 and 85 contain data and specifications on trip control, counting, high temperature, environment-proof, rotary selector and splash-proof switches and assemblies, respectively. All incorporate Micro Switch basic switching units.

52. Stud Welding

Gregory Industries, Inc., Nelson Stud Welding Div.—Offered to facilitate the selection of welding studs, "Cost Saver Kit" includes large wall chart which lists parts numbers and dimensions of stock threaded MG studs and ceramic ferrules. Various tools for gun welding these fasteners are also shown.

53. Diesel Engines & Generators

Nordberg Mfg. Co.—Illustrated bulletins 208, 209-A, 210, 211, 212, 213, 214, 215, 216, 217, 218, and 219 give specifications of 6 to 30-kw diesel generators, 10 to 45-hp diesel engines, diesel power units with clutch power take-off and diesel pump units with capacities up to 2500 gpm at 45-ft head.

54. Precision Resistors

Ohmite Mfg. Co.—Specifications and features of ¼ to 1-w type 85 Riteohm encapsulated precision resistors are contained in 2-page illustrated bulletin No. 145. These wire-wound resistors have axial leads, and type 86 units have lug terminals.

55. Photoprinting Machine

Peck & Harvey Mfg. Co.—P & H Copy-Master office-size Whiteprinter is available in two floor models and will reproduce same-size copies of anything written, drawn, typed, printed or photographed on cut or roll stock. Details of this ammonia type machine are presented in 4-page illustrated bulletin No. 54C5.

56. Industrial Rubber Products

Raybestos-Manhattan, Inc., Manhattan Rubber Div.—Rubber products for industry is subject of illustrated catalog 25-C. Design and application data are given on V-type, transmission and conveyor belts; all types of hose; molded products and rubber pipe flanges. Also described is the new Poly-V drive which combines the simplicity of flat belts with the grip of V-belts.

57. Packings & Gaskets

Johns-Manville—"Chempac Packings & Gaskets" is title of 6-page illustrated guide to properties and applications of these Teflon-treated asbestos materials which are virtually unaffected by corrosive chemicals and active solvents. Information is given on Chempac interlocked packings; coil, spiral and ring packings; folded gaskets for glass-lined equipment; and Spirotallic flange gaskets for high pressure service.

58. Guide Bushings

Lamina Dies & Tools, Inc.—6-page illustrated folder B4 contains prices and dimensions of line of hardened steel, bronze plated guide bushings for use with precision tool steel pins. These precision guides will not seize or score, and they assure accurate alignment.

59. Glass Fiber Yarns

Libbey-Owens-Ford Glass Co. — "Textile Yarns" is title of 8-page illustrated bulletin which deals with properties, applications and comparisons of available L-O-F Fiber-Glass yarns produced by the continuous filament process. Yarns are used both as plastics reinforcements and in production of glass fiber fabrics.

60. Guide to Flame-Plating

Linde Air Products Co.—Flame-plating is a process for depositing thin coatings of tungsten carbide on surfaces of parts and many tools where extra resistance to wear is required. The correct application methods, economies and advantages of this process are related in 16-page illustrated bulletin F-8065B.

61. Solderless Wiring Terminals

Kreuger & Hudepohl—Illustrated folder "K & H Solderless Terminal Lugs" shows how these double-cupped washer lugs fold over ends of wire to form a good electrical terminal. Wire is confined and lug can be attached to equipment under binding screws or nut. Styles are available for practically any terminal need.

62. Precision Controls

Kohler Co., Precision Controls Div.—24-page illustrated bulletin is descriptive of hydraulic, pneumatic and other types of check valves. Also covered are jet engine components and engine primers as well as plug, on-off, angle needle, selector and restrictor valves. Engineering data are given on these aircraft, industrial and automotive components.

63. Electric Power Supplies

Vickers, Inc., Vickers Electric Div.—Magnetic-amplifier selenium-rectifier regulated direct current power supplies in ratings from 5 to 50 kw are subject of 4-page illustrated bulletin 8000. Units operate on 230 and 460-v ac and deliver 125 or 250-v dc output.

64. Cylinders for Automation.

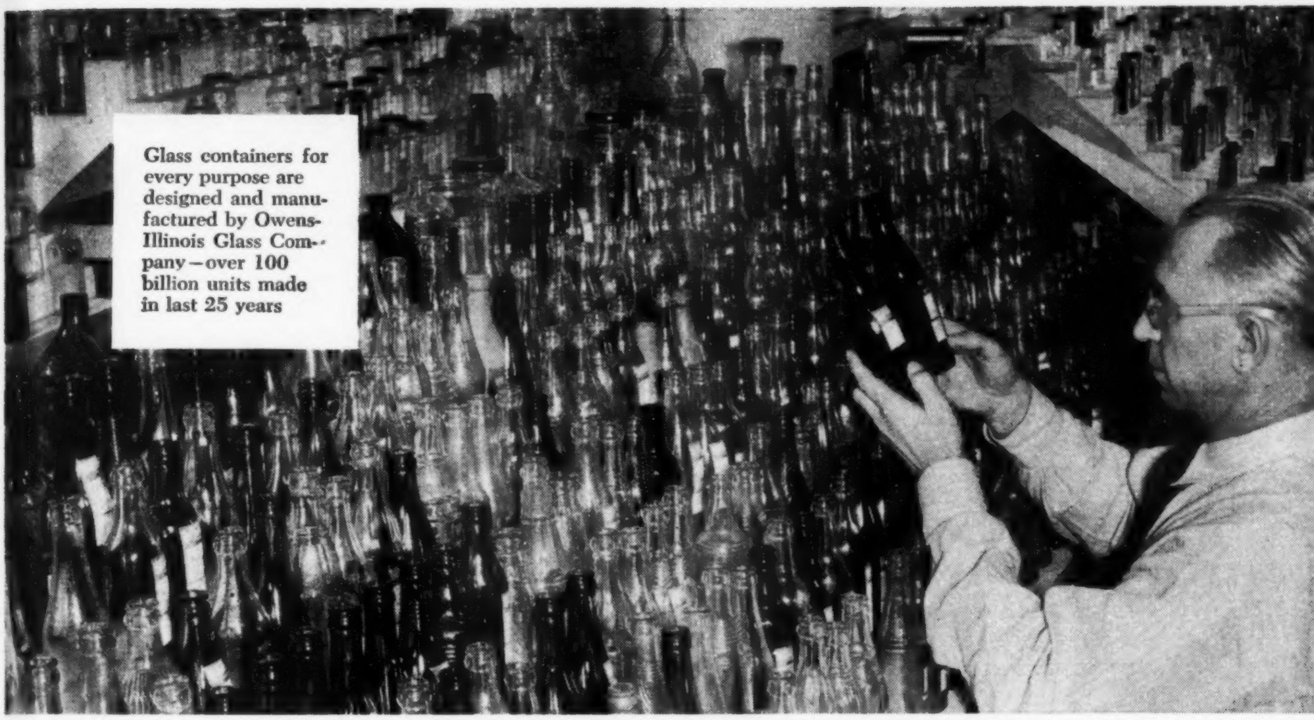
Miller Fluid Power Co.—Entitled "A Cylinder Program for Automation and Heavy Duty Service," 12-page illustrated bulletin discusses standardization of air and hydraulic cylinder mountings, stroke lengths and stock sizes. Interchangeable detachable mountings for automation are covered.

65. Ball Bearing Pillow Block

Link-Belt Co.—The new model JPS 200 ball bearing pillow block with a pressed steel housing is offered for shaft diameters from ⅝ to 1¼ in. for use where speeds are relatively low and loads are light. Details are given in 4-page illustrated bulletin 2517.

66. Cylindrical Roller Bearings

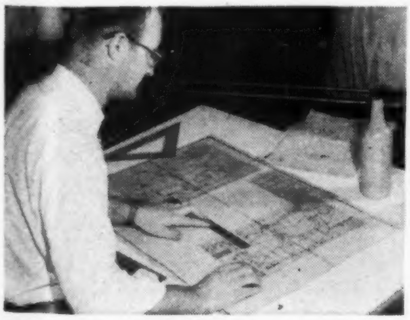
Rollway Bearing Corp.—Illustrated catalog TR-854-DC lists Tru-Rol bearing types, sizes, dimensions and load ratings. Use of crowned rollers relieve high-stress areas at roller ends. Method for calculating expected bearing life is given.



Glass containers for every purpose are designed and manufactured by Owens-Illinois Glass Company—over 100 billion units made in last 25 years

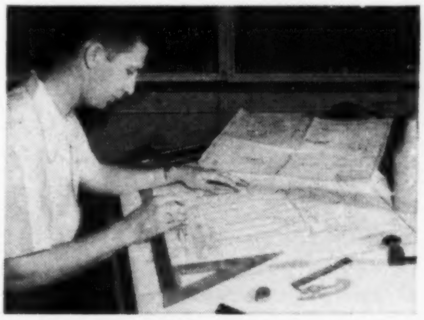
More than 3,000 new designs per year
—without a "bottleneck" in drafting

In the Design Development Department of the Owens-Illinois Glass Company, Toledo, Ohio, no time is lost in tedious redrafting. A simple short cut involving the use of Kodagraph Autopositive Paper and Kodalith Film *gives customers fast service . . . saves dollars every day.* Chances are you can adapt this technique to your own routines.



Big head start. Kodalith Film prints of elements which are repeated from time to time are kept on file. When a new design calls for any of these elements, the draftsman merely tapes the right films on clear acetate *and orders an Autopositive*. No redrafting!

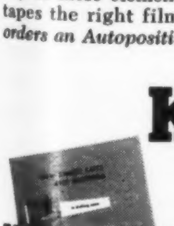
A positive photographic intermediate is produced *directly* by exposing the "paste-up" in contact with Kodagraph Autopositive Paper, then processing the print in standard photographic solutions. No negative step . . . *easy room light operation.*



New design is added to the Autopositive, which has dense photographic black lines on a clean white translucent base. Required number of shop prints—each crisp and uniform—are produced from this master, which can also be used later on for minor revisions.

Kodagraph Autopositive Paper

"THE BIG NEW PLUS" in engineering drawing reproduction



Shows all the ways you can save with Kodagraph Autopositive Paper.

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Industrial Photographic Division, Rochester 4, N. Y. 19

Gentlemen: Please send me a copy of "New Short Cuts and Savings."

Name__________ Position__________

Company__________ Street__________

City__________ Zone_____ State__________

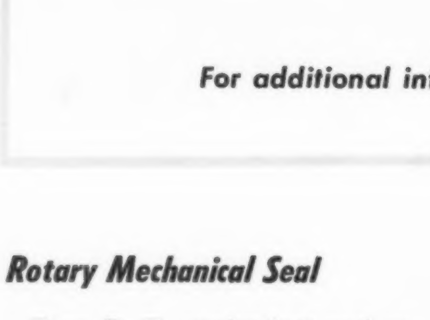
Kodak

NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 241

Rotary Mechanical Seal

Type P. T. mechanical seal retains fluids under pressures ranging from 50 to 600 psi and at temperatures from −80 to 400 F. The rotary unit can be fabricated from various metal alloys for handling all types of fluids except molten alkali metals and some fluorine compounds at high temperatures. Mounting requirements are a cut-down shaft or stub sleeve



and a packing space of ½-in. clearance or larger. Made by **Durametallic Corp.,** 2104 Factory St., Kalamazoo, Mich.

For more data circle MD-67, Page 241

Reversing Drum Switch

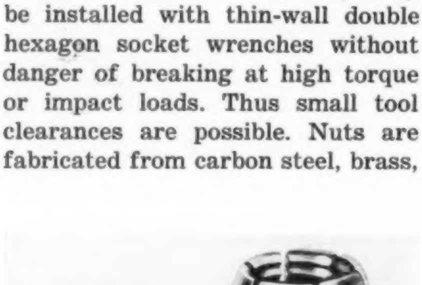
Positrol instant reversing drum switch can be used to reverse single phase condenser start or polyphase motors up to 2 hp and dc motors up to ¼-hp. Special circuit and momentary contact pole in this switch, which is connected to the condenser motor centrifugal switch, accomplishes

instant reversing of the motor shaft when the switch is operated. Made by **Gayston Corp.,** 1221 Ray St., Dayton, O.

For more data circle MD-68, Page 241

Plain and Self-Locking Nuts

Because Twelve-Pointer nuts distribute wrench load, they may be installed with thin-wall double hexagon socket wrenches without danger of breaking at high torque or impact loads. Thus small tool clearances are possible. Nuts are fabricated from carbon steel, brass,



aluminum or stainless steel with plain or special surface finishes. All popular sizes are available in plain nuts (left), as well as Hug-lock self-locking nuts with prevailing torque (right) and Marsden free-running locknuts. Made by **National Machine Products Co.,** 44225 Utica Rd., Utica, Mich.

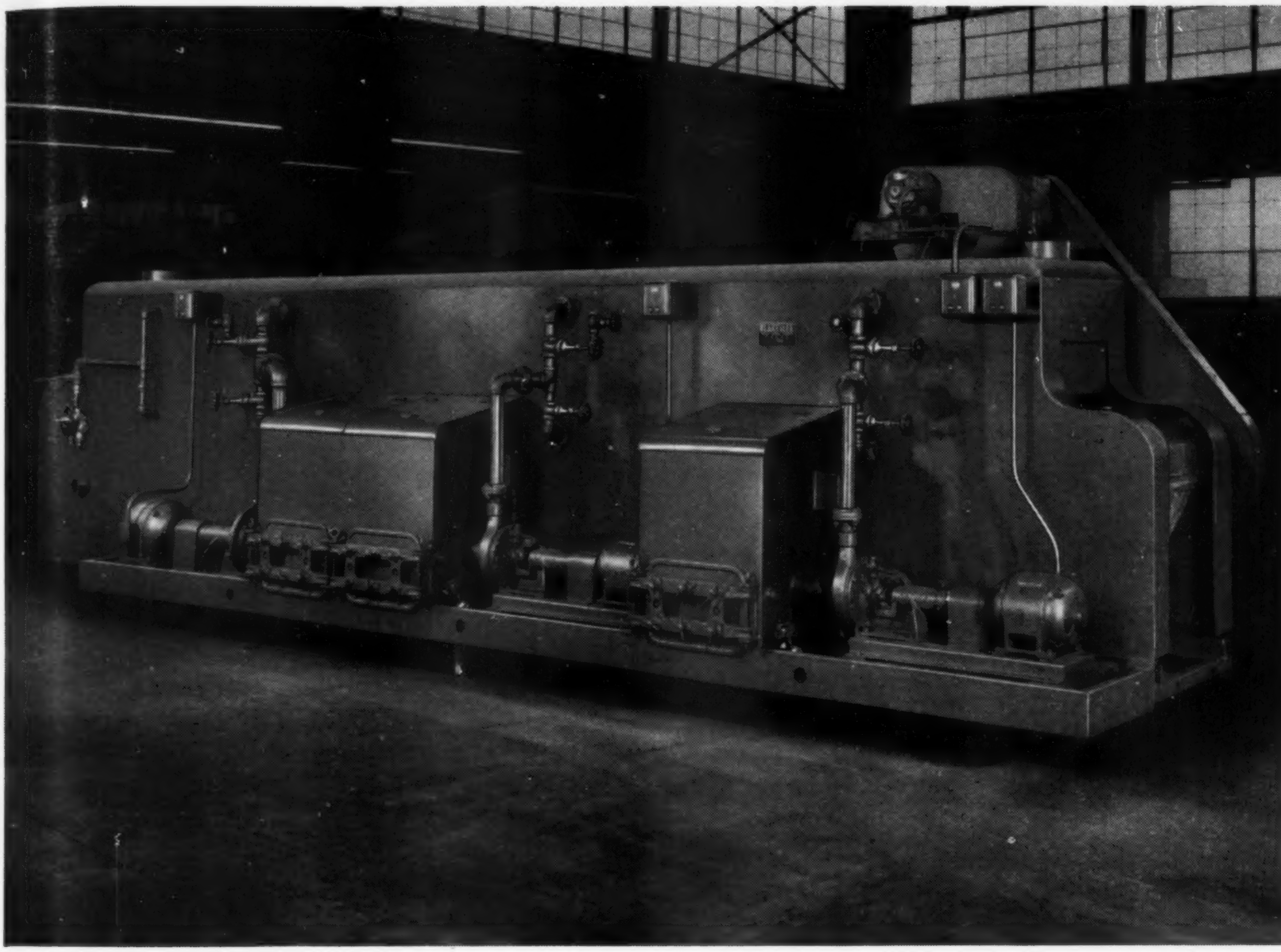
For more data circle MD-69, Page 241

Cam Clutches

Series HT cam clutches for indexing applications on stepped shafts in a wide variety of machinery drives are self-contained

units. Clutch includes a single row ball bearing to help maintain concentricity of inner and outer races. Shape of clutch cams prevents cam roll-over under peak or torsional loads, and low locking angles on cam faces assure self-energizing action of each cam.

An auxiliary energizing spring assures energizing of all cams under light loads and varying conditions. If ultimate torque capacity is exceeded for a short period of time, the unit acts as a torque limiting device and slips without galling the outer race. Supplied for either right or left-hand drive, clutches are made in three stand-



You'll always find Crane Valves on Blakeslee Equipment

Like so many equipment designers and manufacturers, G. S. Blakeslee & Co. consistently specify Crane piping items for their metal parts washers and solvent vapor degreasers. For their interest is in the steady dependability of Blakeslee equipment, and not in the dubious savings of bargain valves. And how many times it's a two-sided story, with equipment buyers insisting on Crane for the very personal reason of past outstanding service.

Crane 150-Pound Brass Gate Valve . . . in a modern, streamlined design. A highly dependable, tight-seating valve with an accurately guided rising stem. Cylindrical upper body is same basic shape as Crane high-pressure steel valves for greater strength and rigidity. In sizes up to 3 inch.

Good Piping Design Begins Here . . . Your Crane Catalog

Nowhere else can you find such a wide variety of top-quality piping materials...properly indexed and arranged to save you time. And with each item you get complete data . . . sizes, dimensions, information on materials—plus clearly defined service recommendations to simplify your selection. Make it your regular reference.

THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

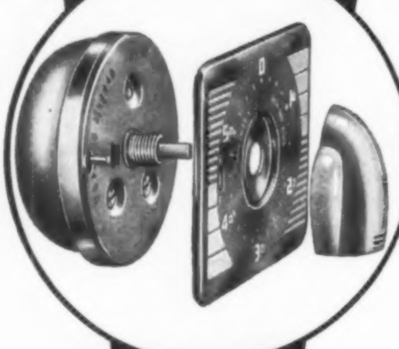
VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Give your appliances this EXTRA VALUE ...at NO extra cost!

MARK-TIME

two-speed

BELL TIMER



Normally supplied with Center Stud mounting.

The exclusive, patented 2-speed feature of this Mark-Time unit makes it TWO timers in one! . . . and puts more "sell" into your appliances!

Here's why: in the long-time position, the user can measure time up to ONE HOUR for baking, roasting, stewing and other lengthy cooking operations . . . can use it as a reminder for appointments and other household jobs, too! By moving the lever to the short-time position, the user can obtain settings within seconds for boiling eggs, pressure cooking . . . precise timing for all short time jobs up to SIX MINUTES, where even fractions of a minute are important.

At the end of the pre-set time period, in either long or short range, this timer gives a clear, resonant bell signal.

Available with a wide variety of modern dials and knobs; also in 2-hour, 12-minute range.

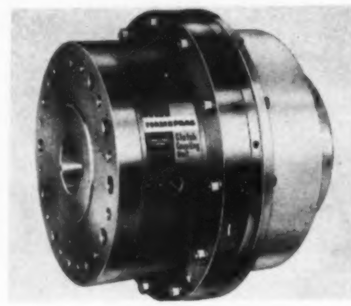
Write today for full details and prices.

MARK-TIME

M. H. RHODES, INC.

HARTFORD, CONNECTICUT

Manufactured and sold in Canada by
SPERRY GYROSCOPE OTTAWA, Limited
3 Hamilton St., Ottawa, Ontario, Canada

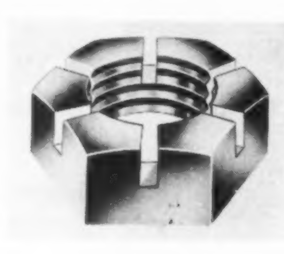


separate lubrication systems for both clutch and coupling to prevent damage to both package halves in event of leakage. Capacities range from 21 to 12,079 lb-ft torque. Maximum speeds are correspondingly from 6000 to 2100 rpm. Made by **Formsprag Co.,** 23601 Hoover Rd., Van Dyke, Mich.

For more data circle MD-75, Page 241

Reusable Locknut

This one-piece, free-spinning, reusable locknut locks itself when seated. Upper portion of nut is slotted, while bottom face is under-cut. When nut is tightened,



threaded upper segments move inward, causing nut to lock onto screw threads with vibrationproof grip. Locknuts are available in all machine screw sizes in steel, brass or aluminum. Made by **Jacobson Nut Mfg. Corp.,** Kenilworth, N. J.

For more data circle MD-76, Page 241

Stainless Steel Valve

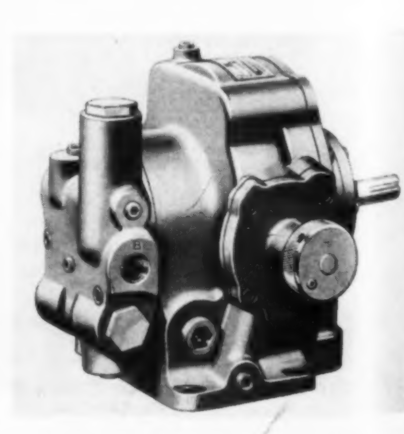
Stainless steel, solenoid-operated, two-way valve with high corrosion resistance controls gases and liquids at pressures up to 250 psi. Valve is normally-closed type. Heavy-duty construction makes these Bulletin 8265 valves suitable for operation at a frequency of 400 times per minute. Solenoids of floating core construction minimize core chatter. Continuous-duty Class A coils for temperatures to 212 F are provided, and high-temperature Class H coils are supplied for temperatures to 450 F. Available in 3/8-in. IPS, solenoid enclosures meet NEMA standard watertight requirements. All internal parts of valve are readily accessible without

removal of valve body from pipe line. Made by **Automatic Switch Co.,** 391 Lakeside Ave., Orange, N. J.

For more data circle MD-77, Page 241

Variable-Delivery Pumps

One and two-way type A variable-delivery pumps are designed for variable-speed, straight-line or rotary-drive applications involving up to 3 hp and requiring precise speed or pressure control or both. Eight types of controls mount integrally with either side of the



DO YOU HAVE YOUR COPY OF THE NEW COMPO® STOCK LIST?

This Stock List is the direct result of 70 years of our manufacturing records of billions of bearings produced for the leaders of American Industry. You too will be pleased with the 20 pages of latest information. Write for your copy today.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

Why waste compressed air at 90 psi where 50 psi *will do a better job ?...*

...and

- ***reduce wear on air equipment***
- ***save dollars on air costs***

USE NORGREN PRESSURE REGULATORS

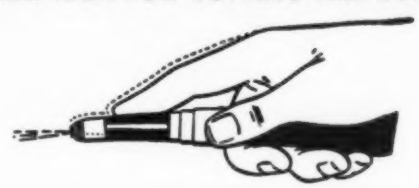
Norgren Regulators more than pay for themselves in savings in air costs alone. More important—they accurately control air pressures to assure proper operation of equipment and minimum maintenance costs. Available in wide range of remote control, low pressure, relieving and cylinder gas types.

WRITE FOR CATALOG SHEET 7-10

C. A. Norgren CO.
3442 So. Elati, Englewood, Colo.

PIONEER AND LEADER IN OIL-FOG LUBRICATION FOR 26 YEARS

ANOTHER IDEA FOR CUTTING AIR COSTS



A blow gun with 90 psi line pressure uses 10½ cfm of air. 30 psi usually does the job just as well and uses only 4½ cfm . saving 6 cfm every minute. On one gun used an average of one hour per day the saving would be 90,000 cu. ft. of air per year.

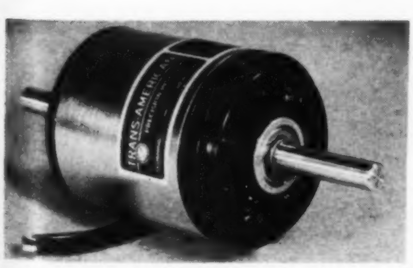
VALVES • FILTERS • REGULATORS • LUBRICATORS • HOSE ASSEMBLIES

be controlled with a maximum of 3 w, since most of the power required is applied to the reference phase. Motors meet pertinent JAN specifications for resistance to humidity, salt spray, fungus, shock and vibration. Made by **Diehl Mfg. Co.**, Somerville, N. J.

For more data circle MD-80, Page 241

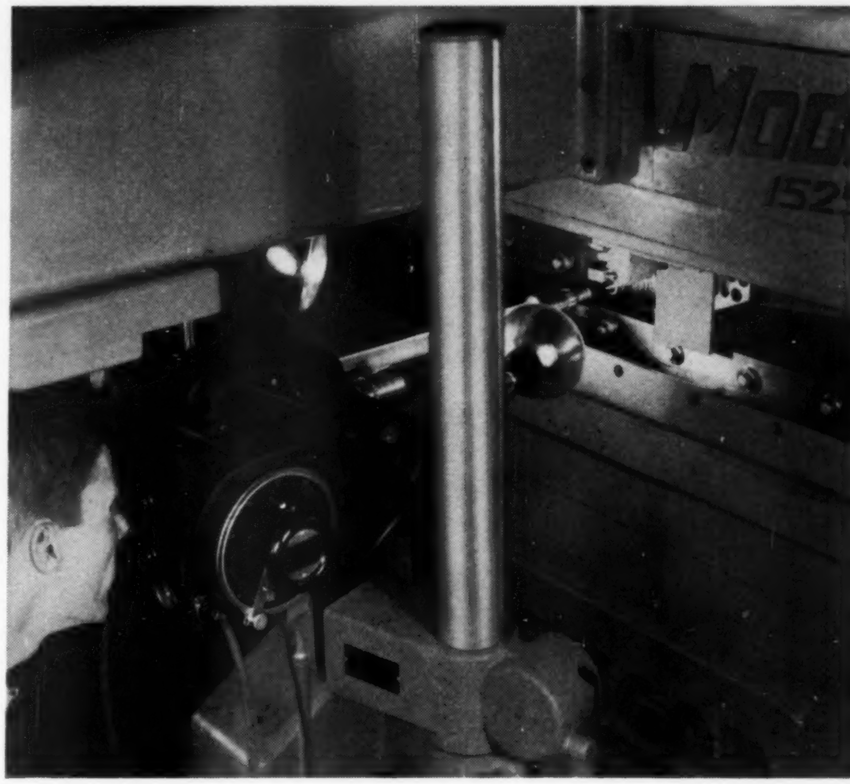
Magnetic Clutch

Model T500 magnetic clutch is a precision electromechanical component for use in such devices as high-accuracy computers and servo systems. It meets all environmental and vibration tests covered by military specifications. Couplings are designed so that they will not induce angular displacement error into the system upon engagement. Input and output shafts are



magnetically coupled when coil is energized. Typical operating characteristics at 24 v dc include maximum output torque range of 110 oz-in.; no-load engagement time of 3 milliseconds and power consumption of 3 w. Under test at 400 cycles per minute with a 4-lb-in. load, clutch exhibited no decrease in performance after 1 million cycles. Clutch can cover a wide range of torque-to-current

(*Continued on Page* 258)



This camera helps *Michigan Tool* roll and sell a better spline

Ever try and keep your eye on a hunk of S.A.E. 1037 steel being *rolled* into a splined shaft in 3 seconds?

You can't—too fast to follow. But engineers at the Michigan Tool Company did it by turning a Kodak High Speed Camera on their new Roto-Flo machines in action. With the high speed movies slowing action down as much as 200 times, design engineers were able to study the precise nature of the cold roll forming and then make basic improvements. And the same movies were later used to explain advantages and efficiency of the new system to customers.

The Kodak High Speed Camera that helps Michigan Tool's engineers is a versatile instrument, easy to use, and capable of taking up to 3200 pictures per second. There is an edge-marking internal argon lamp for accurate time checks. The camera can be set up to trigger off the split-second action you want to record.

And the movies are a permanent record that you can study over and over, stop at critical frames.

If one of your product or process projects is blurred in action too fast to follow or show to others, a Kodak High Speed Camera may be the answer. It has worked for such diverse products as paper, beet harvesters, tires, puffing guns, and calculators.

For more about what it can do for you, send for the booklet, "High Speed Motion Picture Making in Industry."

Industrial Photographic Division
EASTMAN KODAK COMPANY, Rochester 4, N. Y.

the Kodak
***HIGH SPEED* Camera**

Kodak


new
. . . and more efficient, too!
• Custom-designed for regular production!
• Built for a lifetime of service!
LELAND LOADSTAR MOTORS
Here are LELAND'S outstanding qualifications for producing the finest of motors to the new NEMA standards:
★ Extensive and continuing experience in developing and producing, for our Armed Forces, hundreds of thousands of portable generator units and airborne inverter units and controls. Leland designs consistently meet and frequently surpass specifications so satisfactorily that they virtually become the criteria for other suppliers.
★ More than 33 years' "creative electrical engineering" experience in supplying manufacturers with high-quality custom-built special motors, or standard LELAND motors adapted to the particular requirements of their products.
★ The combined, industry-wide engineering and development resources of American Machine & Foundry Company.
★ A unique combination of modern, mass-production facilities and custom craftsmanship, resulting in extra care in critical operations and greater versatility in production.

Hitch your product to a "Loadstar"!

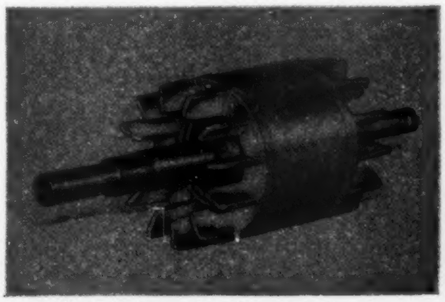
YOUR NEWEST PRODUCT will have added value, added efficiency, when powered by the equally modern, equally efficient LELAND *"Loadstar"!* It's the most advanced LELAND motor ever designed for regular production!

LELAND engineers have taken full advantage of the rare opportunity presented by the reframing program to incorporate into new LELAND designs many *added* improvements not actually a part of simple reframing. In this way every user of a new *"Loadstar"* motor benefits directly from LELAND's exceptionally pertinent experience in the continuing development and manufacture of special and lightweight power units and inverters for Aviation and the Armed Forces... one of the roles in which LELAND's creative electrical engineering has particularly distinguished itself.

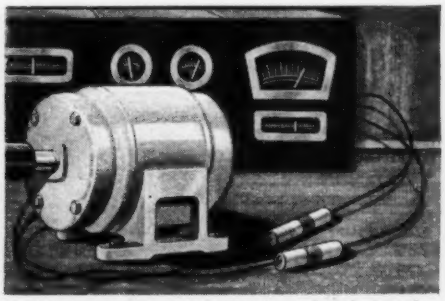
No wonder, then, that the *"Loadstar"* outshines them all!

Some features of this new line of smaller, lighter integral horsepower motors are shown below. Others were covered in a previous advertisement. For the complete story, and frame dimension details, write for Bulletin No. 103.

Generous-sized, double-shielded, sealed ball bearings, *lubricated for life,* prevent entrance of abrasive grit. Precision-machined bearing bores give uniform rotor-to-stator air gap.

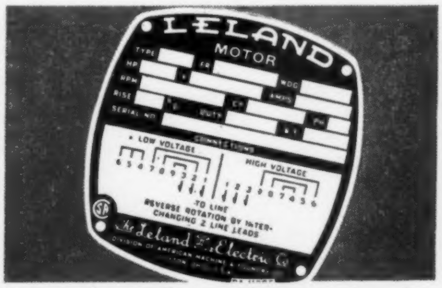


Simplified design: reduced number of parts; cast fans have same diameter as rotor, permitting rotor removal from either end; standardized components fit open or enclosed frames.



Performance tests prove, despite reduced size, the new motors attain higher efficiency, higher full-load speeds, approximately 30% higher starting torque and breakdown torque.

Stator construction features heavy Formvar windings and carefully annealed lamination punchings.



Non-rusting, easily read aluminum name plate plainly shows all wiring connections.

Large conduit box turns to four positions. Smudge-proof numbered markers identify leads.

New "Loadstar" polyphase, dripproof motors in 1, 1½ and 2 HP (180 frames) now ready. Totally enclosed and explosion-proof frames—also higher horsepower and single phase motors—available soon.

Another AMF Product

LELAND MOTORS

LELAND motors in previous NEMA standard frames will continue to be available for replacement and the convenience of present customers.

THE LELAND ELECTRIC COMPANY, DAYTON 1, OHIO, *Division of American Machine & Foundry Company*

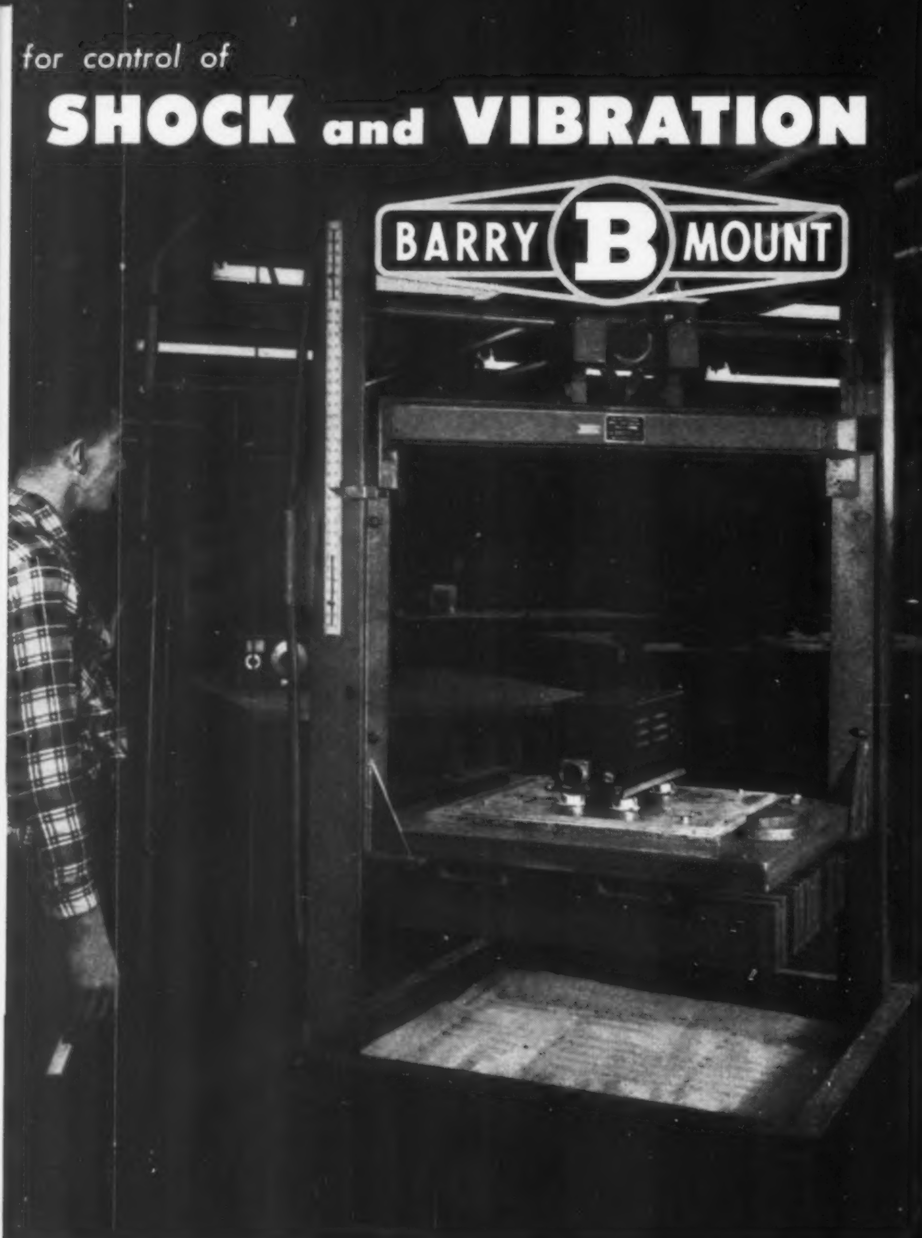
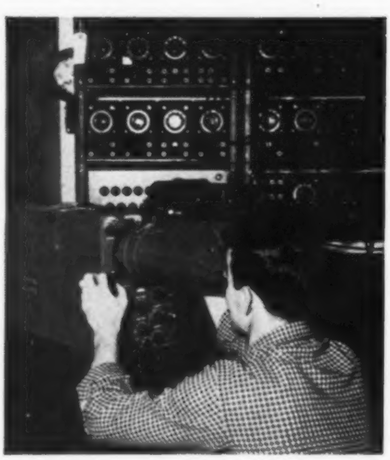


Photo courtesy Bell Aircraft Corporation

How to assure the operation of a pilotless bomber



One way — used by Bell Aircraft Corporation — is to subject every component to a multitude of tests so as to minimize possibility of failure. Barrymounts® that protect delicate electronic equipment, and Barry VD impact-shock machines that provide high accelerations for tests, play an important part in the production of the guided missiles that Bell Aircraft has designed and is manufacturing.

For assured protection of your electronic devices, we can furnish standard Barrymounts® or can develop and manufacture special units for your particular needs. And we can furnish shock-testing equipment for your use or we can conduct your tests in our shock and vibration laboratory. *Write for Bulletin BA-54.*

THE BARRY CORP.

722 PLEASANT STREET
WATERTOWN 72, MASS.

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

New Parts

(*Continued from Page* 255)

ratios. Made by **Trans-American Precision Instrument Corp.**, 34-17 Lawrence St., Flushing 54, N. Y.
For more data circle MD-81, Page 241

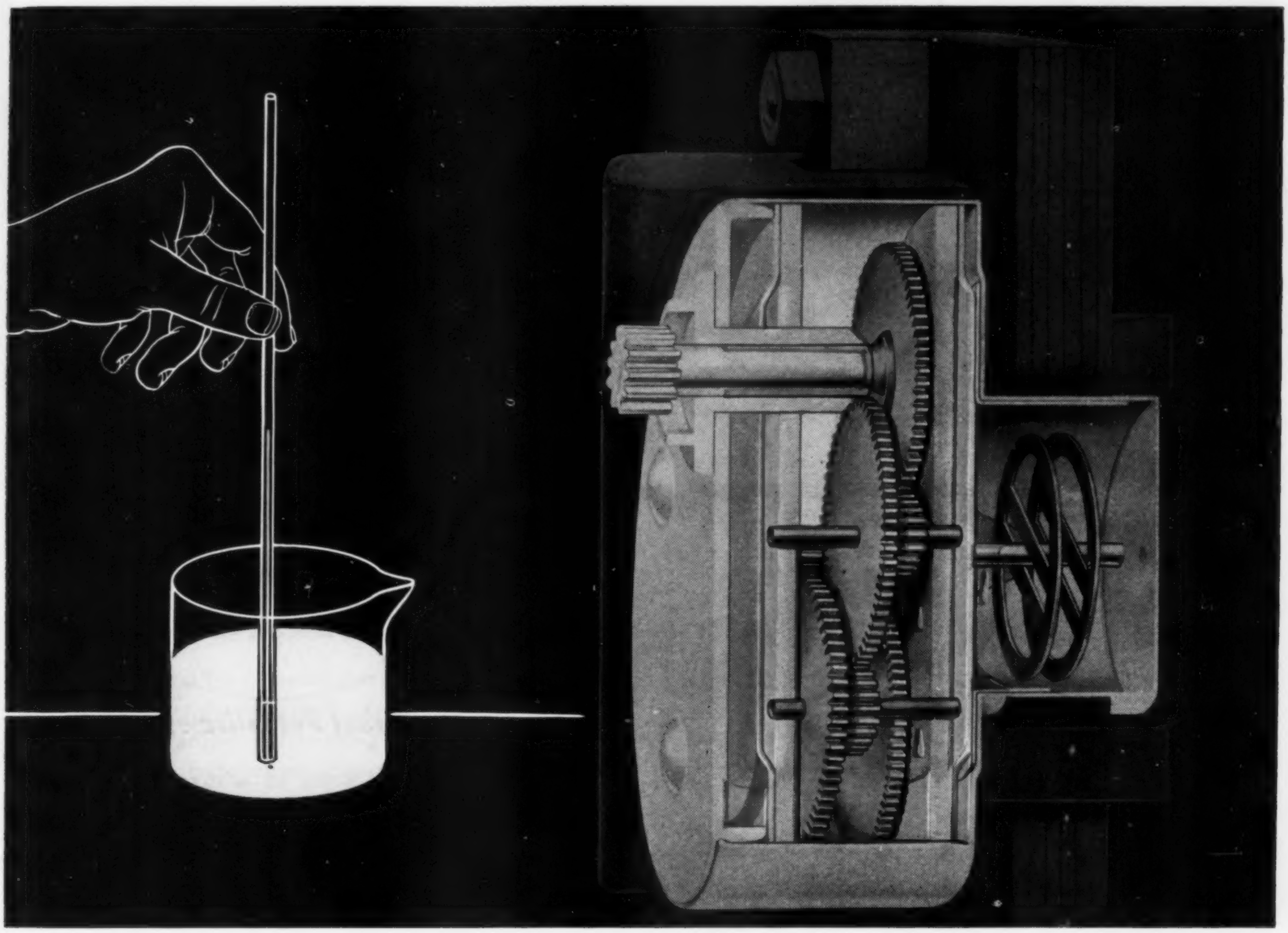
Automatic Float Unit

Series 150 snap-action automatic float units for separating moisture and other contaminants from compressed air are now available for 1/4 to 3-in. lines. Operating pressures are 10 to 250 psi with almost any air volume. Simplified units

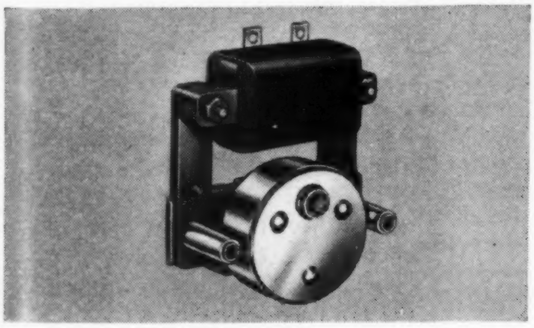
fit into small space. They are designed for continuous or intermittent flow and operate without pressure drop or flutter. Float is employed just to trigger moisture discharge rather than actually to open and close the port. Built-in filter screen protects operating parts against rust and grit. Made by **Wilkerson Corp.**, 3377 S. Platte River Dr., Englewood, Colo.
For more data circle MD-82, Page 241

Miniature Remote Control

Miniature mechanical chain and sprocket system permits motion transfer through several planes simultaneously. Stainless steel



***MORE* evidence of the extra *VALUE* in *TELECHRON* timing motors...**



Lubrication is only part of the Telechron motor story. Lightweight rotors assure quick starting. Gears are hobbed for quiet operation. Power-line accuracy means true synchronous performance. Separation of the field from the rotor results in cooler operation and longer life.

The accurate, dependable, inexpensive Telechron Synchronous Motor is the heart of timing you see everywhere . . . in clock-radios, washers and dryers; in heating controls, refrigerator defrosters and air conditioners . . . in industrial time switches, recorders and instrumentation.

CAPILLARY ACTION FEEDS OIL TO MOVING PARTS

One secret of the lasting accuracy of a Telechron timing motor is its exclusive sealed-in system of lubrication.

Each Telechron motor carries just the right amount of oil, locked-in against dirt and dust. The oil is drawn up the spaces between bearings and capillary plates by the same free-flowing process that pulls water up the hollow stem of a plant—or a glass tube. Bearings are constantly covered with a thin coating of oil.

This way the oil lasts the life of the motor—which, with a Telechron timing motor, can be for years and years.

Write for complete catalog and full information on our Application Engineering Service. Telechron Department, General Electric Company, 212 Homer Avenue, Ashland, Mass.

Telechron®

MARK OF TIMING LEADERSHIP

YOU NAME IT-

FELT

by FELTERS

will do it...

Filters
Auto parts
Washers
Noise dampeners
Wicks
Packings
Liners
Electrical appliances
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Shock absorbers
Vibration controls

(Your product goes here)

Resiliency that permits constant spring-back to original shape . . . and good absorptive characteristics . . . are just two of the many properties you can get in Felt made by Felters.

If you have a problem that could be solved by a soft, porous material, or by a hard, dense material — your answer could well be a Felt made by Felters.

The "Felters Design Book" describes several usual and unusual uses for Felt. Drop us a line and we will send you a copy.

HEARD ABOUT ***UNISORB®*** *— THE MODERN MACHINERY MOUNTING?*

The **FELTERS** Company
218 South Street, Boston 11, Mass.

New Parts

corrosion-resistant chain operates accurately and smoothly around a minimum of a seven-tooth sprocket with a root diameter of ¼-in. Chain pitch is 0.1475 in. and weight is 0.45-oz per ft. Standard sprockets for incorporation in drives or controls are available from stock with 7 to 45 teeth and 0.250 to 2.024-in. root diameters. Special sprockets can be supplied. Solder type fittings are used to join standard 1/16 and 3/64-in. aircraft cable to end of chain for multi-plane motion transfer over pulleys. Made by **Sierra Engineering Co.,** 123 E. Montecito Ave., Sierra Madre, Calif.

For more data circle MD-83, Page 241

Spiral Potentiometer

Usable as a direct replacement for applications requiring stepless operation, Spiralpot is an infinite-resolution slide wire potentiometer.

Available in three or ten-turn models with resistance ranges of 6 to 2500 ohms and linearities within 0.1 and 0.05-per cent, units have low operating noise because of slide-wire action. Power rating for ten-turn unit is 5 w; torque is 2 oz-in. or less. Made by **G. M. Giannini & Co. Inc.,** 918 E. Green St., Pasadena 1, Calif.

For more data circle MD-84, Page 241

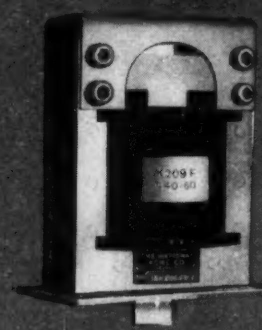
Air Clutches

Utilizing a minimum amount of air for operation, single and double plate model Air-Grip clutches are available with ratings from 8.5 to 806 hp per 100 rpm at 80 psi. Air-operated units have quick action and ability to "inch" or be thrown into full engagement. Instant disengagement is achieved by use of optional quick-release valves built

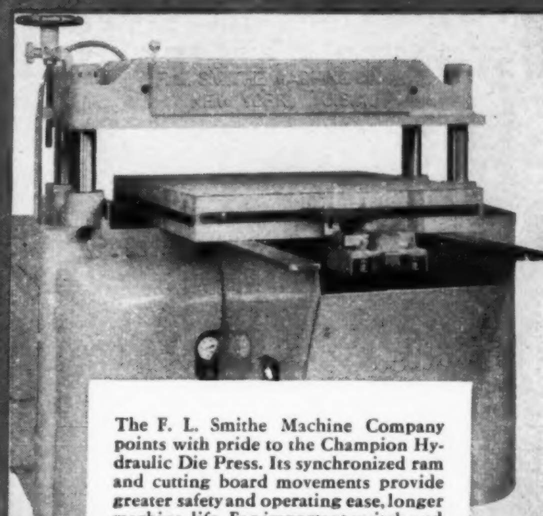
dependable NAMCO

"STELLITE"-WELD

Solenoids



do those hidden jobs *Automatically*



The F. L. Smithe Machine Company points with pride to the Champion Hydraulic Die Press. Its synchronized ram and cutting board movements provide greater safety and operating ease, longer machine life. For important switch and solenoid components, they chose Namco Snap-Locks and "Stellite"-weld solenoids.

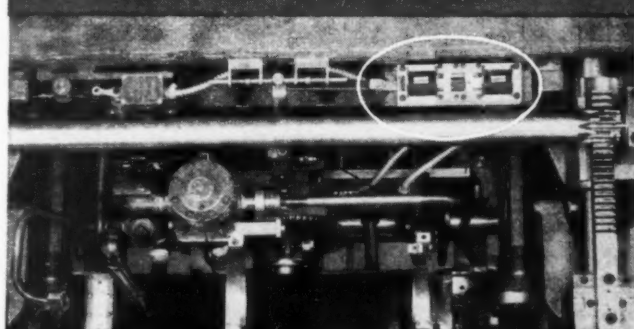
Solenoids offer you a modern, up-to-date way of doing jobs automatically, by remote control—even in cramped quarters. You can simplify design, manufacture and operation—with the positive, accurate action of Namco "Stellite"-weld Solenoids.

Many manufacturers with a cost or space problem have found the solution in these compact reliable solenoids. They're using them in the place of expensive and bulky gear trains, levers, linkages and other mechanisms. They're getting better products (usually at lower costs) by using Namco Solenoids to

ACTUATE CLUTCHES	ACTUATE CLAMPING
OPERATE SWITCHES	HOLD CHUCKS
CONTROL MACHINES	OPERATE VALVES
MOVE LEVERS	VIBRATE CUTTING KNIVES
PRINT SYMBOLS	OPEN AND CLOSE DOORS
OPERATE SAFETY DEVICES	OPEN AND CLOSE HOPPERS
EJECT WORK IN PROCESS	SORT INSPECTED PARTS

Namco "Stellite"-weld Solenoids are built in sizes with ratings from $2\frac{1}{2}$ to 25 pounds, push or pull, at maximum 1" stroke. We'll be glad to recommend the size and style best suited to your job—ask our engineers to talk it over with yours.

Engineering BULLETIN EM-52 gives details on standard Namco Solenoids.



Packaging machines, shearing devices, valves, envelope machines and many others perform better longer with Namco Solenoids. "Stellite"-weld and hard chrome plate bonding on plunger, sturdy construction and highest quality coils make Namco Solenoids long lived, rugged, DEPENDABLE.

ACME-GRIDLEY
BAR and CHUCKING AUTOMATICS
1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • Limit, Motor Starter and Control Station Switches • Solenoids • Contract Manufacturing

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The NATIONAL ACME COMPANY

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BIJUR

AUTOMATICALLY ASSURES CUSTOMER SATISFACTION

the user of your machines

- Increases Productive Capacity
- Saves on Repair Bills
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- Reduces Downtime
- Lengthens Machine Life

With Bijur Automatic Lubrication as an integral part of your equipment, your customers benefit from continuous peak production. Plant after plant reports increased out-put and greatly reduced maintenance costs with Bijur-equipped machines. Costly downtime for lubricating by hand is eliminated. Every bearing is metered the proper quantity of oil at predetermined intervals. Work spoilage and bearing troubles caused by over-lubrication are avoided. Fire hazards are reduced. Personnel accidents are prevented.

Bijur gives you the opportunity to add customer satisfaction through improved machine performance.

More than a million Bijur-protected machines are in use. Hundreds of leading manufacturers standardize on Bijur as "built-in" components of their machines. Bijur emphasizes custom-engineering, and we will gladly cooperate in designing a system to meet the specific requirements of your machine.

Design Bijur into your machines now in production or in the planning stage. Write for literature and engineering information.

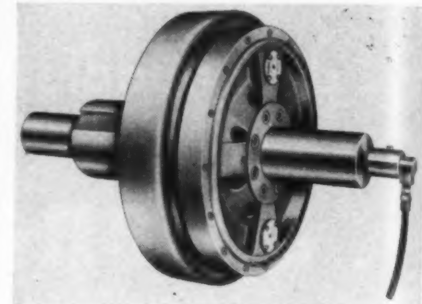
O-3

2369

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

New Parts



into the clutch. Provision is made for internal ventilation. Mechanical engagement is possible in the event of air supply failure. These clutches can be interchanged with and used to replace mechanical clutches in existing installations. Made by **Dodge Mfg. Corp.,** Mishawaka, Ind.

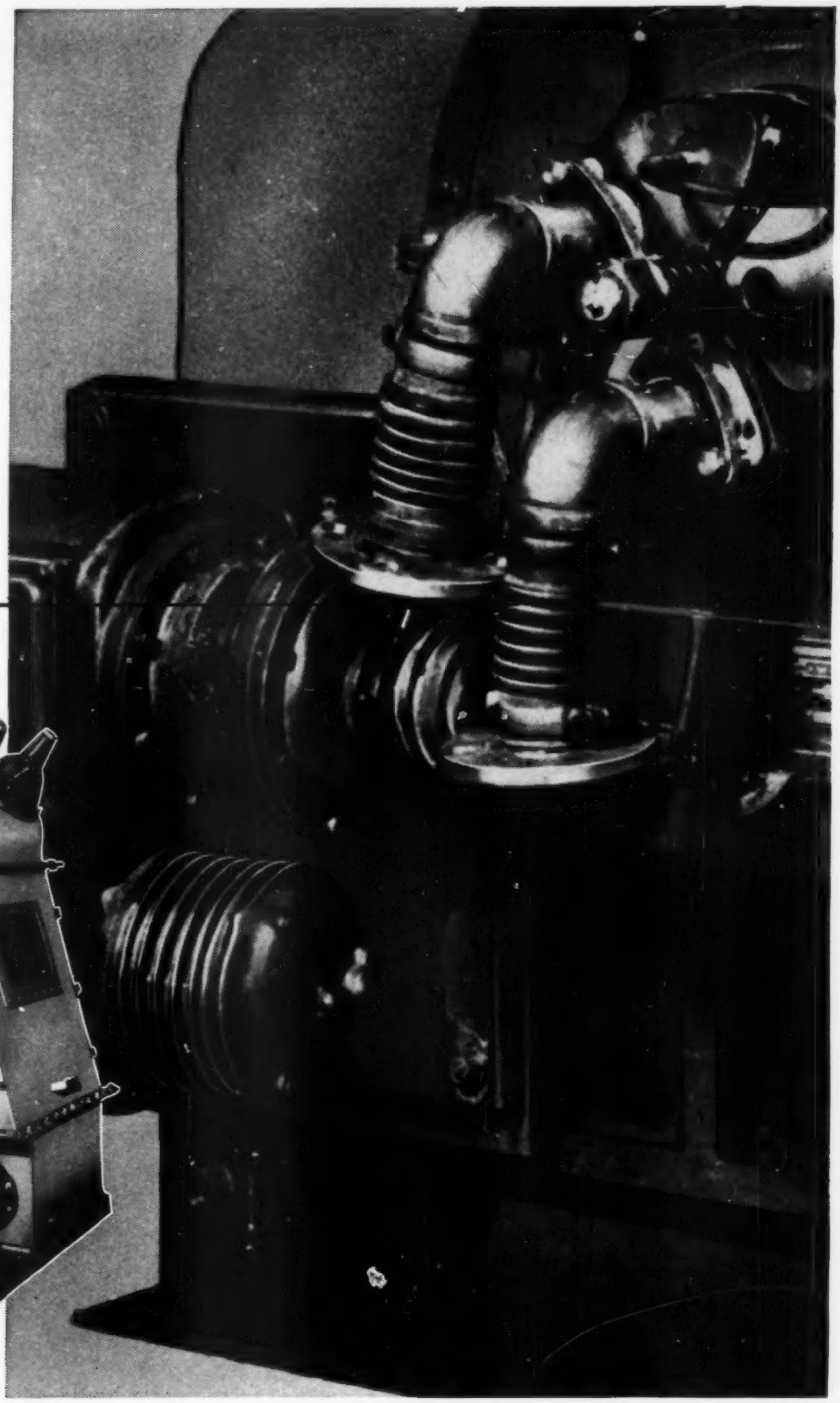
For more data circle MD-85, Page 241

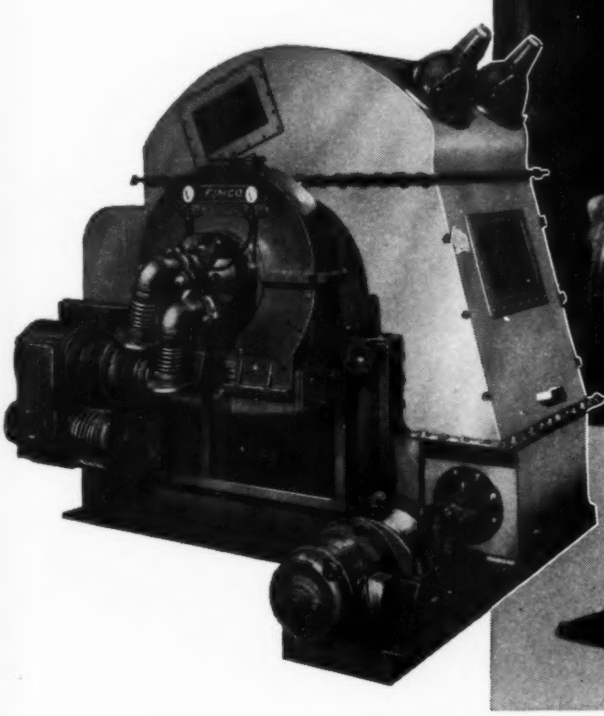
Oil Mist Lubricator

Micro-Fog lubricator for air-operated equipment has easily adjustable variable vane venturi which enables one unit to meet the requirements of a wide range of operating conditions and handle applications which previously required several sizes of lubricators.

Unit lubricates only when air flows, providing a fine fog of oil particles no larger than 2 microns in diameter. New line includes 20 models in pipe sizes of 1/4, 3/8, 1/2, 3/4 and 1 in., with capacities of 1/2-pt, 1 3/4 gal and 4 1/2 gal and flow range from 5 to 250 cfm at 80 psi. At this same pressure, the 3/8-in. size can be set for a low flow range of 5 to 9 cfm, a high range of 50 to

Short-cut to Flexibility... with U. S. Multi-Flex Connectors





Now the equipment designer can turn out a more efficient, trouble-free product — with U. S. Multi-Flex® Connectors. Here's one example: The vacuum filter shown above uses these connectors to take care of axial movement caused by compression and extension *and* to allow for misalignment.

Developed by United States Rubber Company, Multi-Flex Connectors need no molds or specially-tooled mandrels. Multi-Flex Products are made of rubber, or rubber and fabric, in sizes from ¼" to 36" I. D.

Other Multi-Flex products fill a wide range of needs, including many which cannot be met by conventional means. Among these are air ducts, protective boots, connectors for conveying air or liquids, corrugated tubing and bellows for moving air.

For engineering advice, call on any of our 27 District Sales Offices or write to address below for a free copy of our Multi-Flex Catalog.

"U.S." Research perfects it...
"U.S." Production builds it...
U.S. Industry depends on it...

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UNITED STATES RUBBER COMPANY
MECHANICAL GOODS DIVISION · ROCKEFELLER CENTER, NEW YORK 20, N. Y.

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*Tucson, Arizona
Tucson Bearing Co., Inc.

IN CANADA, *Montreal, Quebec, John Braidwood & Sons, Ltd. *Stocks Carried.

ESTABLISHED 1915

OHIO GEARS

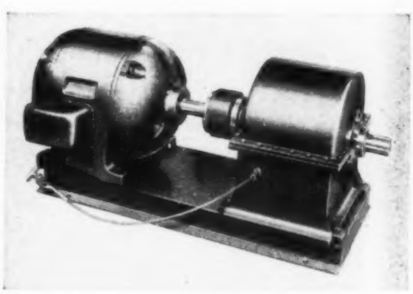
OHIO GEAR CO. • 1338 E. 179th ST. • CLEVELAND 10, OHIO

100 cfm, or any intermediate range. Lubricator has transparent dome for visibility of oil feed and transparent oil bowl for visibility of oil supply. An auxiliary air circuit accurately controls oil feed from 1 drop in 20 minutes to 15 drops per minute. Made by **C. A. Norgren Co.,** 3400 S. Elati St., Englewood, Colo.

For more data circle MD-86, Page 241

Variable-Speed Coupling

Model VSL Power Mate variable speed liquid drive transmits power from motor driveshaft through fluid medium contained within the coupling unit by means of impeller and runner rotors. Amount of fluid contained within working elements determines amount of energy transmitted. This fluid varia-

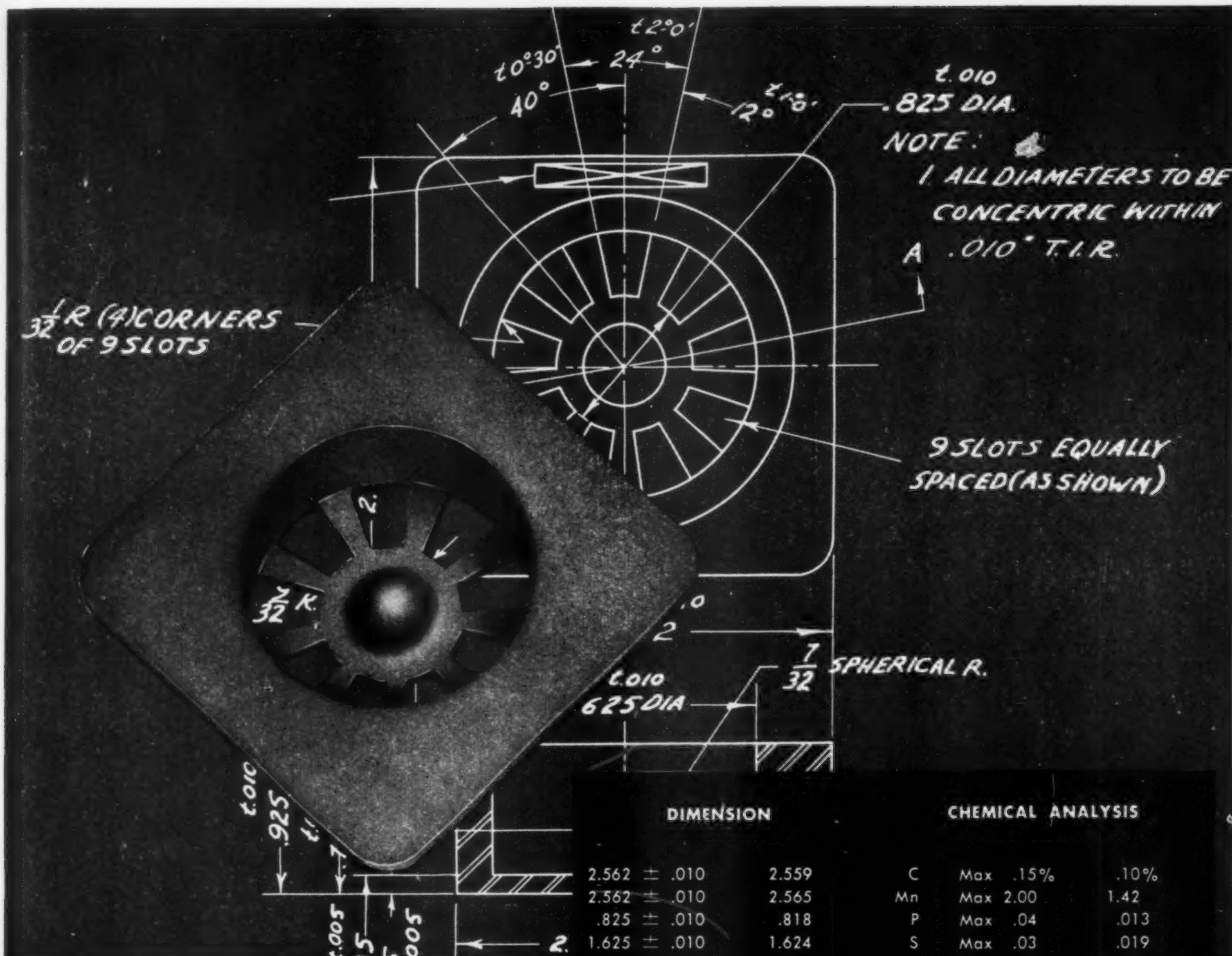


tion is controlled by a scoop tube device. The drive unit provides control of speed, acceleration and load; rapid declutching of driven equipment; adaptability to automatic control; no-load starting; and shock and overload protection through fluid slippage factor. Six models with ratings from 1 to 150 hp operate at speeds from 750 to 1800 rpm. Made by **Liquid Drive Corp.,** Holly, Mich.

For more data circle MD-87, Page 241

Appliance Safety Switch

Hazards in overturning of heaters and other portable electric appliances are minimized by Stemco Tip-Off switch which mounts in base of appliance with single bolt or rivet. A pin or similar device projecting through appliance base and pressing against lower contact



DIMENSION		CHEMICAL ANALYSIS		
2.562 ± .010	2.559	C	Max .15%	.10%
2.562 ± .010	2.565	Mn	Max 2.00	1.42
.825 ± .010	.818	P	Max .04	.013
1.625 ± .010	1.624	S	Max .03	.019
.925 ± .010	.924	Si	Max .75	.61
.700 ± .010	.698	Ni	12.00-14.00	13.00
.105 ± .005	.109	Cr	16.00-18.00	17.70
2.050 ± .010	2.058	Cu	Max .50	.07
.295 ± .005	.293	Mo	1.50-2.25	1.96

Rely on

Crucible ACCUMET investment castings

for dimensional and metallurgical accuracy . . .

This intricately shaped aircraft instrument part had to be held to rigid specifications both in size and in chemical analysis of the steel.

That's why Crucible ACCUMET® precision castings were used. For Crucible's *lost wax* method of casting, and its long experience as the country's leading producer of fine special purpose steels, combine to bring you accurate castings of the highest quality. But the two tables shown below actually tell the story better than words can. They show how closely ACCUMET castings are held to original specifications.

The next time you have a job where quality and close tolerances are needed, be sure to investigate the advantages of ACCUMET precision castings — *call Crucible.*

Buy U.S. Savings Bonds

CRUCIBLE first name in special purpose steels

54 *years of* *Fine* *steelmaking* **ACCUMET INVESTMENT CASTINGS**

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MAX-EL • SPECIAL PURPOSE STEELS

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Over 62 years... PHILLIE GEAR ®

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Add to these "Phillie Gear's" Courteous Service and Prompt Delivery, and you have a combination hard to beat . . . So, for Gears of any size or quantity, ***consult "Phillie Gear".***

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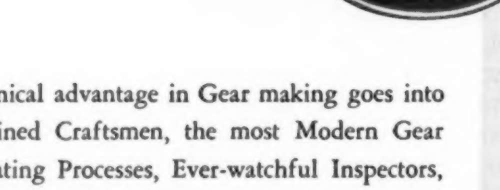
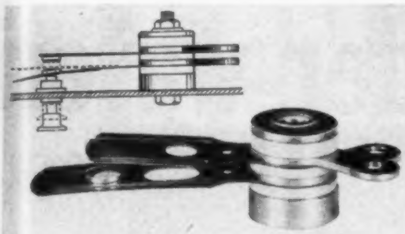
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA.



Industrial Gears & Speed Reducers

LimiTorque Valve Controls

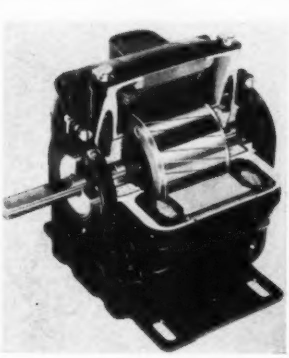


spring closes contacts. The instant appliance is overturned or lifted from floor, spring opens contacts to switch unit off. Stainless steel contact springs have spot welded silver contacts that last lifetime of appliance. A-MP or screw type terminals of various styles are available. Made by **Stevens Mfg. Co.**, 69 S. Walnut St., Mansfield, O.

For more data circle MD-88, Page 241

Small Electric Motors

High starting torque in shaded pole AY and BY motors is obtained through the Tri-Flux design, which includes main pole flux-path, flux-path through shaded part of pole and flux-path through reluctance recess cut into leading edge of each salient pole.

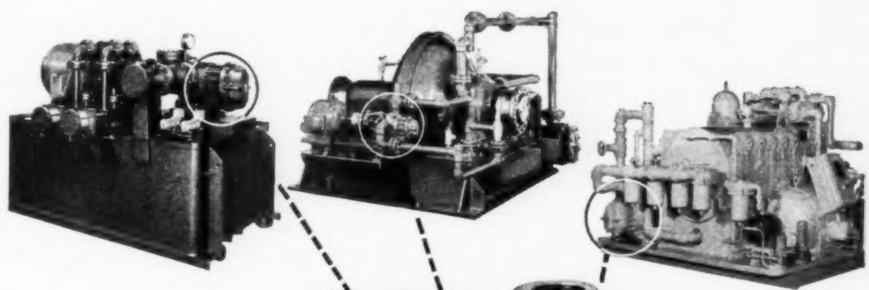


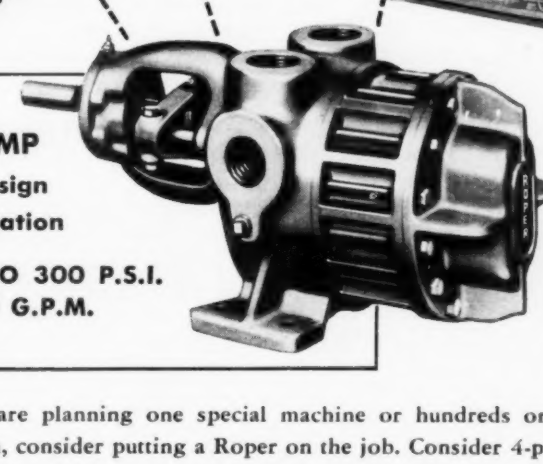
Rated from 1/15 to 1/6-hp, these MicroMotors have Uni-Cast field construction in which laminations are stacked and die-cast together to form rigid field structure. This contributes to extreme low noise level in operation. Motors also incorporate precision bored steel-back babbitted bearings, oversized oil reservoirs, rapid heat dissipation through press-fit between bearing and case-bell, eight lead wire positions for varied installa-

(*Continued on Page* 270)

ROPER *Rotary Pumps* POWER *That's Dependable*

POSITIVE CONTROL *for Hydraulic Circuits*





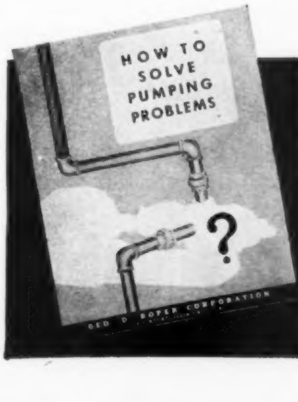
SERIES F PUMP
with 4-port design for Easy Installation

PRESSURES TO 300 P.S.I.
SIZES 1-300 G.P.M.

Whether you are planning one special machine or hundreds on a production run, consider putting a Roper on the job. Consider 4-port design of the Series F (eight optional piping arrangements — 4 for CW and 4 for CCW rotation) for ease of installation and servicing. Consider, too, the Roper principle of only two moving parts . . . equal size gears operating in axial hydraulic balance . . . standard or stainless steel fitted models, as desired . . . heavy duty flange type bearings. Pumps are supplied with or without relief valve . . . with packed box or mechanical seal. Yes . . . consider Roper for *your* hydraulic applications.

Send for Your Free Copy of New Roper Fact-Packed Booklet!

A valuable 36 page guide that includes tables, charts, and other data relative to the average pumping job. Send for your free copy . . . use coupon below.



Geo. D. Roper Corporation
252 Blackhawk Park Ave.
Rockford, Illinois

Please send copy of your latest catalog and new booklet "How To Solve Pumping Problems".

NAME..

ADDRESS..

CITY.............................STATE............

J&H Motors run under water

HERE WAS THE NEED

Kenco, Inc., pump manufacturer of Lorain, Ohio, needed a special motor to power a new portable sump pump. The pump was designed to automatically discharge water from sumps, flooded basements, boiler room pits, transformer vaults, septic tanks and excavations.

The pump, designed to operate *completely submerged*, provides maximum pumping capacity with minimum size and weight.

To meet the severe demands of underwater operation and maximum portability, the following special motor requirements were essential: Unique provision for heat dissipation, positive moisture seal and utmost electrical efficiency.

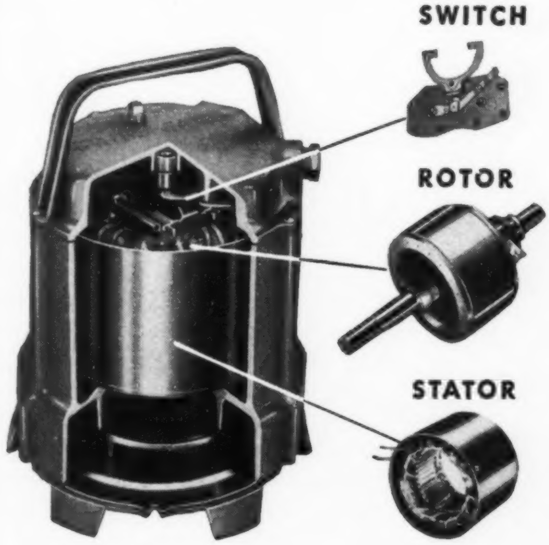
Customized JACK & HEINTZ

in KENCO Sump Pumps!

Manufacturer reports outstanding results!

Kenco and Jack & Heintz engineers combined their knowledge and skills in designing a *Customized* motor to fit the unusual needs of a new sump pump. The motor provides the pump with trouble-free operation, minimum size and weight, high torque characteristics and features necessary for underwater operation. In addition, the motor gives the pump a capacity of 3,300 gallons per hour at 10-ft head—substantially above the design objective. This is another example of J&H ingenuity in custom designing a motor to fit a specific product.

These 5 J&H Customized Motor features assure **KENCO** *complete dependability:*



1 To dissipate heat developed in stator and rotor, motor is hermetically sealed in a watertight case and filled with insulating oil. Heat transfer is from motor-to-oil-to-outer case-to-liquid.

2 Rotor shaft machined to close tolerances to meet customer's locating dimension and to insure accurate assembly of impeller on shaft. A watertight seal is assured through careful mating of motor and pump parts.

3 Rotor vent holes baffled to avoid wasteful pumping of oil. Cooling fins omitted to eliminate friction loss and absorbed power—provides 90 watts gain in terms of electrical performance.

4 Stator slot and lead wire insulation especially selected for oil-immersion operation. Low moisture absorption is a feature of all materials selected.

5 Oversized special alloy switch contacts, for operation in oil, provide positive action and long life.

HERE IS THE RESULT—

A rugged J&H Motor, incorporating *Customized* electrical and mechanical features, is an integral part of each Kenco Pump. Submerged in water, each pump is hydrostatically tested at 10-psi internal air pressure; waterproofness is guaranteed to a depth of 23 feet.

DESIGN YOUR PRODUCT TO DO A JOB...

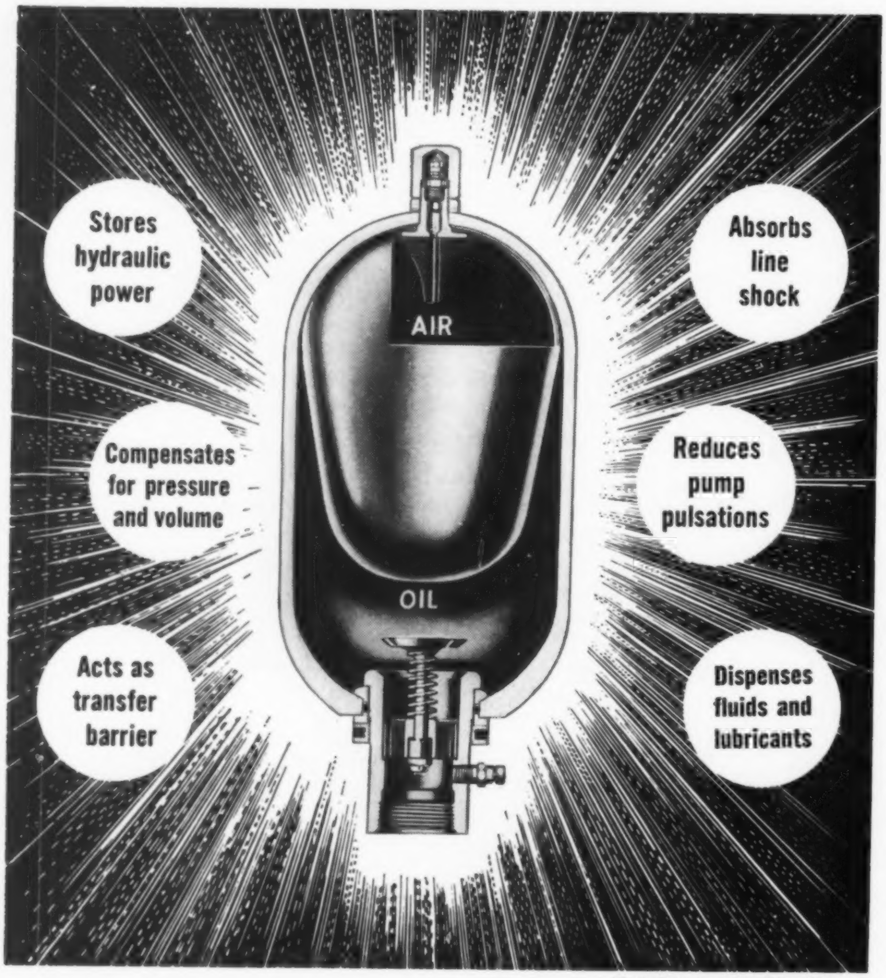
not to fit a motor

Avoid compromising your product design by taking advantage of an engineering philosophy geared to solve your special motor needs. Design your product to do a job . . . *not to fit a motor!* Write Jack & Heintz, Inc., 17626 Broadway, Cleveland 1, Ohio.

©1954, Jack & Heintz, Inc.

ELECTRIC MOTORS

MOST VERSATILE HYDRAULIC COMPONENT EVER DEVISED!

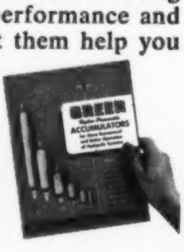


U. S. Patents under Olaer Licenses

The Greer Accumulator

Today, Greer Accumulators are at work in almost every industry you can name. They are found in the hydraulic systems of buses, construction machines, ships, planes, submarines, and flying missiles. They power all types of presses, control steel processes, operate electric switches, absorb pulsations in oil pipelines—to mention a few of hundreds of applications.

Greer Accumulators can reduce the cost, size, weight, and complexity of your machines and equipment. And Greer's experienced application engineers know where accumulators belong for use, maximum performance and *complete* safety. Let them help you solve your hydraulic problem. Write or call Greer. No obligation. Brochure 301-A gives technical data on the Greer Accumulator. Ask for your free copy today.



GREER HYDRAULICS INC. • International Airport • JAMAICA 30, NEW YORK
Field offices in Chicago, Dayton and Detroit • Sales Representatives in all principal cities

New Parts

(*Continued from Page* 267)

tions, resilient rubber mountings and springcap oilers. Made by **Redmond Co. Inc.,** Owosso, Mich.
For more data circle MD-89, Page 241

Pilot Operated Valves

Pilot pressure in line of pilot operated, solenoid controlled four-way valves can be external or internal, and changeover is made by rotating the solenoid valve 180 deg. All porting and positioning arrangements in circuits up to 3000 psi can be accommodated.

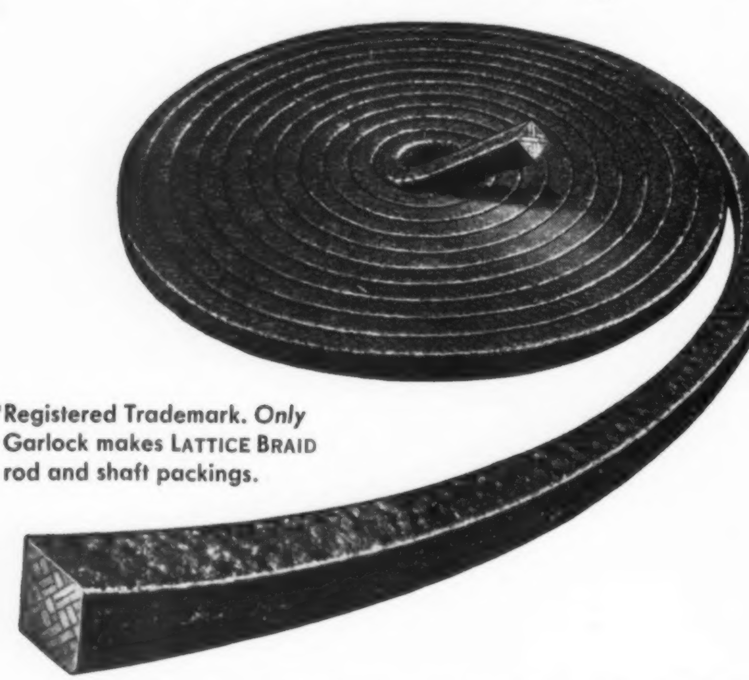
Choice of spool types and spool positioning provides combinations for wide application range. Adjustable pilot chokes for smooth spool reversal are optional. Capacities are 20 gpm and 1¼ gpm for ¾ and ⅛-in. solenoid valves, respectively, and these two series are also available singly. Made by **Denison Engineering Co.,** 1160 Dublin Rd., Columbus 16, O.
For more data circle MD-90, Page 241

Indicator-Controller

Accurate indicating and instantaneous control required by plastic injection molding, extruding, packaging and vacuum forming machines may be furnished by the compact model 297 Wheelco Capacitrol. Both temperature measuring system and control chassis are of plug-in design for easy replacement and servicing without disturbing instrument or external wiring. Balancing adjustment for tuning the alignment index and indicating pointer to exact coincidence, plus adjustment of antic-


It triumphed over the tropics in
SOUTH AFRICA
BROOK MOTORS
are built to win over your climatic conditions, too!
A blazing tropical sun, coupled with the destructive forces of penetrating dust and moisture, can quickly shorten the life of any electric motor . . . unless it is totally weatherproofed to stand up under the severest conditions, outdoors or indoors. Such weatherproofing is a standard operation in the manufacture of every Brook motor . . . for fifty years, the world's most respected motor!
Stator slots and windings are impregnated and baked to resist moisture, dust, heat and cold . . . your assurance that Brook motors will perform successfully in your climate. Every Brook motor is precision built to meet or surpass NEMA standards; uses standard bearings, threads and nuts. All major types are available from stock, in a wide range of horsepower sizes. Brook world-wide service stations have a complete selection of parts . . . every motor can be easily serviced in any shop, anywhere. Always specify Brook . . . the world's most respected motor—built by the world's most experienced manufacturer. Write for a free, colorfully-illustrated Brook catalog today.
FAST DELIVERY OF ALL POPULAR MODELS!
Brook motors are available from warehouses at Chicago, Jacksonville, Hawthorne, N. J., Houston, Los Angeles, San Francisco, Seattle, and other major distributing points.
Open drip-proof
world's most respected motor
1904-1954 . . . respected and used the world over for 50 years!
Splash-proof
Totally enclosed non-ventilated
BROOK MOTOR CORPORATION
Single-phase
Totally enclosed externally fan-cooled
BROOK MOTOR CORPORATION
3555 W. Peterson Ave., Chicago 45, Illinois

Large Manufacturer of Sleeve-Type Expansion Joints standardizes on LATTICE BRAID* Asbestos Packing



*Registered Trademark. *Only* Garlock makes LATTICE BRAID rod and shaft packings.

The James Morrison Brass Manufacturing Company Ltd. of Toronto manufactures among other products, "Beaver" sleeve type expansion joints. These expansion joints are designed to handle steam at temperatures up to 400°F. and pressures up to 250 p.s.i. According to G. R. Gardner, president, Morrison has standardized on LATTICE BRAID asbestos packing for use on these expansion joints because: (1) LATTICE BRAID stands up better under high temperatures and pressures than ordinary braided packings, and (2) the use of LATTICE BRAID eliminates customer complaints on packing.

Put Garlock LATTICE BRAID Packing to work for your company. All the braided strands of this unique packing are lattice linked together into one structural unit. The strands hold together even when the packing is worn far beyond the limits of wear of ordinary braided packings.

LATTICE BRAID is made from flax, cotton, asbestos, wire-inserted asbestos, Teflon, and asbestos with Teflon impregnation—for various types of services.

Get all the facts about LATTICE BRAID *Packings. Contact your Garlock representative or write for new folder AD-131.*

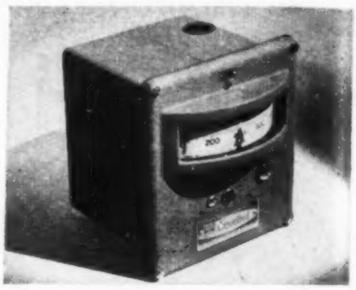
THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Cleveland Denver • Detroit • Houston • Los Angeles • New Orleans • New York City • Palmyra (N. Y.) • Philadelphia Pittsburgh • Portland (Oregon) • Salt Lake City • San Francisco • St. Louis • Seattle • Spokane • Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

GARLOCK LATTICE BRAID PACKING

New Parts

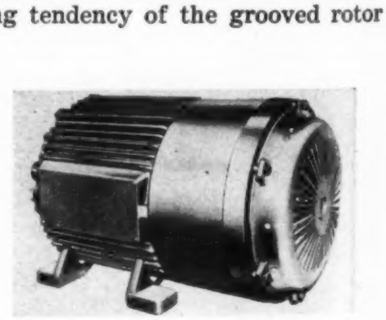


ipatory action cycle time and control setting are accessible from the front. Thermocouple break protection which shuts off the fuel supply in case of thermocouple or lead wire failure, is optional. Made by Wheelco Instruments Div., **Barber-Colman Co.**, 1300 Rock St., Rockford, Ill.

For more data circle MD-91, Page 241

Thrust Brake Motor

Axial thrust for braking action is provided by a coil spring in P & H thrust-brake squirrel-cage and slip-ring motors. Counter-thrust, which takes place as the motor is energized, is accomplished as the result of flux-aligning tendency of the grooved rotor

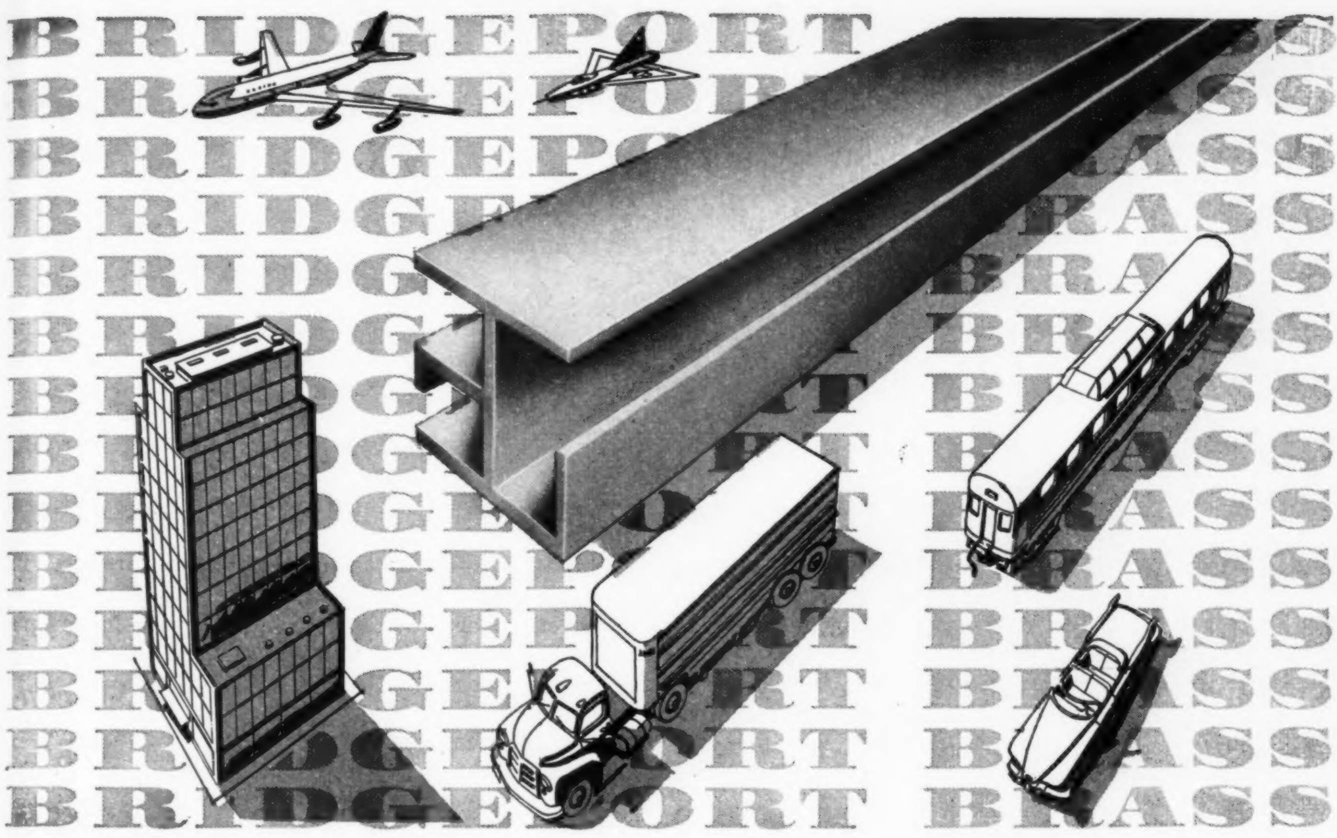


and stator design. Built with integral brake in range of sizes from ¾ to 30 hp, totally-enclosed units meet all NEMA standards. Rotating brake member also acts as a fan for air cooling the motor. Brake release is fast. Made by **Harnischfeger Corp.**, 4607 W. National Ave., Milwaukee 46, Wis.

For more data circle MD-92, Page 241

Pawl Fastener

Requiring only one hole for installation, universal pawl fastener is readily attached to any panel



The shape of things to come . . .

BRIDGEPORT ALUMINUM EXTRUSIONS

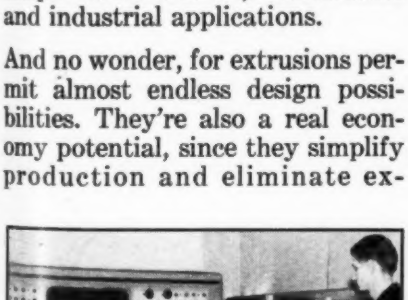
Future-minded designers and manufacturers are looking more and more to extruded aluminum shapes for structural, architectural and industrial applications.

And no wonder, for extrusions permit almost endless design possibilities. They're also a real economy potential, since they simplify production and eliminate expensive machining and assembly operations.

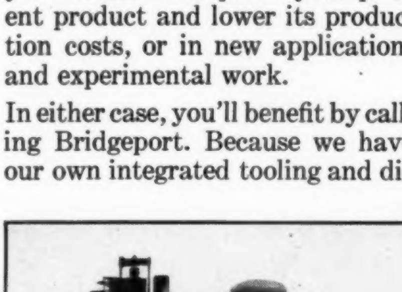
These advantages can work for you—either to improve your present product and lower its production costs, or in new applications and experimental work.

In either case, you'll benefit by calling Bridgeport. Because we have our own integrated tooling and die shops, the cost of custom designs is relatively low. Experienced production personnel and the very latest in quality control, testing, and research equipment assure highest quality extrusions produced to aircraft standards.

For more information on the profitability of using Bridgeport extrusions or for technical assistance in solving your design problems, get in touch with Bridgeport. You'll find a sales office near you.



Every production step is subject to strict quality control at Bridgeport Aluminum. This spectroscope detects alloy elements as low as 0.001 per cent.



This extrusion press—one of 16 at Bridgeport Aluminum—has a capacity of 5,500 tons. Any alloy now being extruded can be supplied.

Bridgeport

BRIDGEPORT BRASS COMPANY
ALUMINUM DIVISION
BRIDGEPORT 2, CONN.

Sales offices in Principal Cities
Conveniently Located Warehouses
Mills at Bridgeport, Conn., Indianapolis, Ind., and Adrian, Mich.

BRIDGEPORT ALUMINUM

BUILT TO LAST...

O-M CYLINDERS (air · hydraulic)

Designed and engineered with the user in mind, O-M Cylinders embody every essential construction and mechanical feature to assure trouble-free performance and long service.

They are built of steel with bearing surfaces of bronze—precision machined with modern equipment.

Cylinder bores are honed to a fine finish, and the hi-tensile piston rods are polished to give long life and smooth performance.

Effective O-ring static seals are backed up to prevent extrusion under high pressures. All packings are self-adjusting and are carefully selected for proper usage.

A rigid inspection at the factory is your guarantee of peak performance.

O-M Cylinders fit where others won't because O-M special interlocking mechanism eliminates bulging tie rods and end caps.

Available in a full range of sizes (1½" to 8" bores) with standard, 2 to 1 or oversize rods. *14-day delivery on most sizes.*

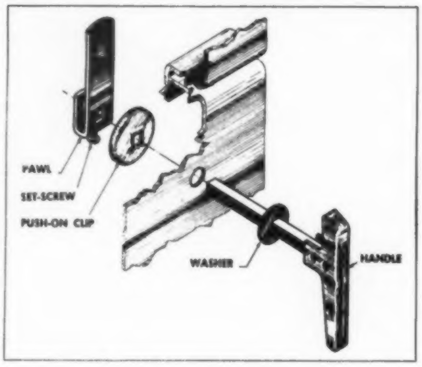
Write today for FREE catalog and complete set of ½ and ¼-scale templates showing all cylinders and mounting brackets.

MAIL COUPON NOW!

ORTMAN-MILLER MACHINE CO.
7 143rd Street - Hammond, Indiana

☐ Please have representative call
☐ Please send latest catalog

Name ____________
Company ____________
Address ____________
City ________ Zone ____ State ________

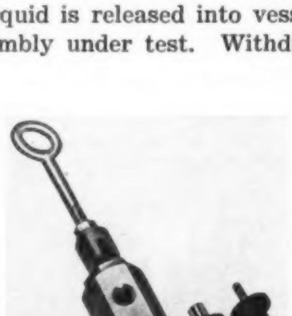


up to 1¾ in. thick. Pawl is adjustable to frame thickness with a single setscrew. Installation requires drilling ¼-in. hole, inserting and slipping a speed clip over the shaft and attaching the pawl to the desired grip length. Longer shaft can be supplied for use with thicker panels. Made by Southco Div., **South Chester Corp.,** Lester, Pa.

For more data circle MD-93, Page 241

Connector Valve

One quick operation connects and seals gas, air or liquid pressure lines to standard openings for testing vessels, systems or assemblies. Inserting the Connecto-Valve into opening and depressing its cam lever simultaneously expands the connecting seal and opens the valve. A leakproof seal is effected and full flow of gas, air or liquid is released into vessel or assembly under test. Withdrawal



of the unit automatically closes the valve. Made of corrosion resistant materials with replaceable Neoprene seals, valve has inlet connections for ⅜-in. pipe pressure lines. Valves are available for sealing ½, ¾ and 1-in. pipe openings. Made by **Mechanical Products Corp.,** 168 N. Ogden Ave., Chicago 7, Ill.

For more data circle MD-94, Page 241

Right-Angle Gear Unit

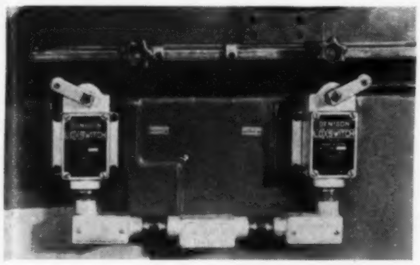
Rated 2½ hp and possessing high load capacity, heavy-duty ANGL-gear right-angle bevel gear unit is designed for use in either power transmission or manually operated assemblies. Unit is available in two and three-way transmission styles. Ball bearing sealed units are lubricated for life and can be flange end-mounted or three-bolt side-mounted in any position. Rated speed is 1200 rpm,

ratio is 1:1 and maximum static torque capacity is 2500 lb-in. Dimensions are 12 x 11¼ x 4 in., including 1-in. diameter shafts. Illustration shows new unit as well as smaller 1/3 and 1-hp units. Made by **Airborne Accessories Corp.,** 1414 Chestnut St., Hillside 5, N. J.

For more data circle MD-95, Page 241

Limit Switches

Used for automating machine tools and conveyors, redesigned series L100 heavy duty limit switches provide 70-degree overtravel in either direction of the lever. Trigger type mechanism with four rotating parts gives fast and accurate break, high contact pressure and minimum of bounce. Switches provide isolated circuits with double-break contacts. Standard model L100S has



single-pole double-throw arrangement which can be used normally-open or normally-closed in either direction, or as maintained contact in both directions. Model L100D is double-pole, with both circuits normally-closed or normally-open. Three-pole switch has two circuits open and one closed or vice versa. Made by **R. B. Denison Mfg. Co.,** 102 St. Clair Ave. N.W., Cleveland 13, O.

For more data circle MD-96, Page 241

Air Control Valve

Lifeguard control valve is an ac solenoid, pilot-operated, three-way model which shuts itself off when any component does not operate normally. Cut-off unit attached to the pilot section casting stops the flow of air to that section in case of failure of any valve part. Valve cannot be actuated again until the seal is broken on the recock unit and necessary adjustments or replacements are made. Valve assembly consists of two valves in a common housing combined with the cut-off unit. It has a single inlet port, a single cylinder or out port, and two interconnected exhaust ports. Two pilot sections with a

common air supply have individual exhaust ports and solenoids. Maximum operating speed is 600 cycles per minute, and main valve pressures range from 30 to 125 psi air, with pilot pressure of 40 to 125 psi air. Maximum operating temperature is 175 F. Inlet pipe size is 3/4-in. Made by **Ross Operating Valve Co.,** Dept. 3101, 120 E. Golden Gate Ave., Detroit 3, Mich.

For more data circle MD-97, Page 241

Permanent Magnet Motor

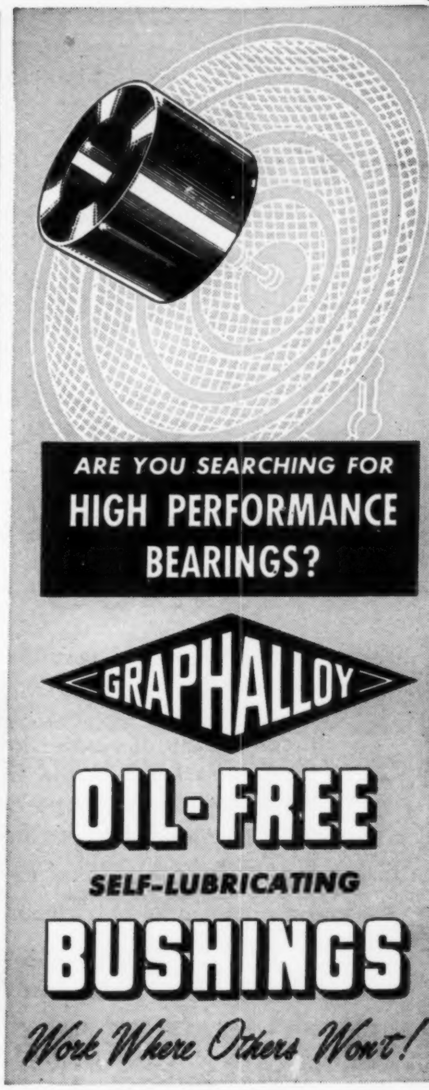
Flange-ring mounting for quick attachment by clamps or retaining rings is offered by type PM-36

permanent-magnet motor. Rated at 27 v dc, motor provides 20-w output at 6000 rpm on continuous-duty cycle, with large overload capacity. Unit has over 60 per cent efficiency, good speed regulation and an internal capacitor to minimize rf interference. It is available in several styles, including those with output shafts with splines, tangs and other arrangements, as well as alternative types of electrical connections. Made by **Dalmotor Co.,** 1347 Clay St., Santa Clara, Calif.

For more data circle MD-98, Page 241

Power Relay

High current-carrying capacity is provided by the use of heavy-duty silver contacts which are riveted to the spring of new type J relay. Hinge type armature provides long life and adjustment stability. A heavy-duty yoke has a stainless steel pivot pin with a



EXCELLENT DURABILITY • CONSTANT COEFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE — EVEN WHERE OIL SOLIDIFIES OR CARBONIZES • OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE OR OTHER LIQUIDS • EXCELLENT FOR CURRENT-CARRYING BEARINGS

GRAPHALLOY materials are also in wide use for oil-free, self-lubricating piston rings, seal rings, thrust washers, friction discs, pump vanes, etc.

Other Graphalloy Products

For applications requiring low electrical noise, low and constant drop, high current density and minimum wear. Used for SELSYNS, DYNAMOTORS, SYNCHROS, ROTATING STRAIN GAGE pick-ups and many other applications. Brush Holders and Coin Silver Slip Rings also available.

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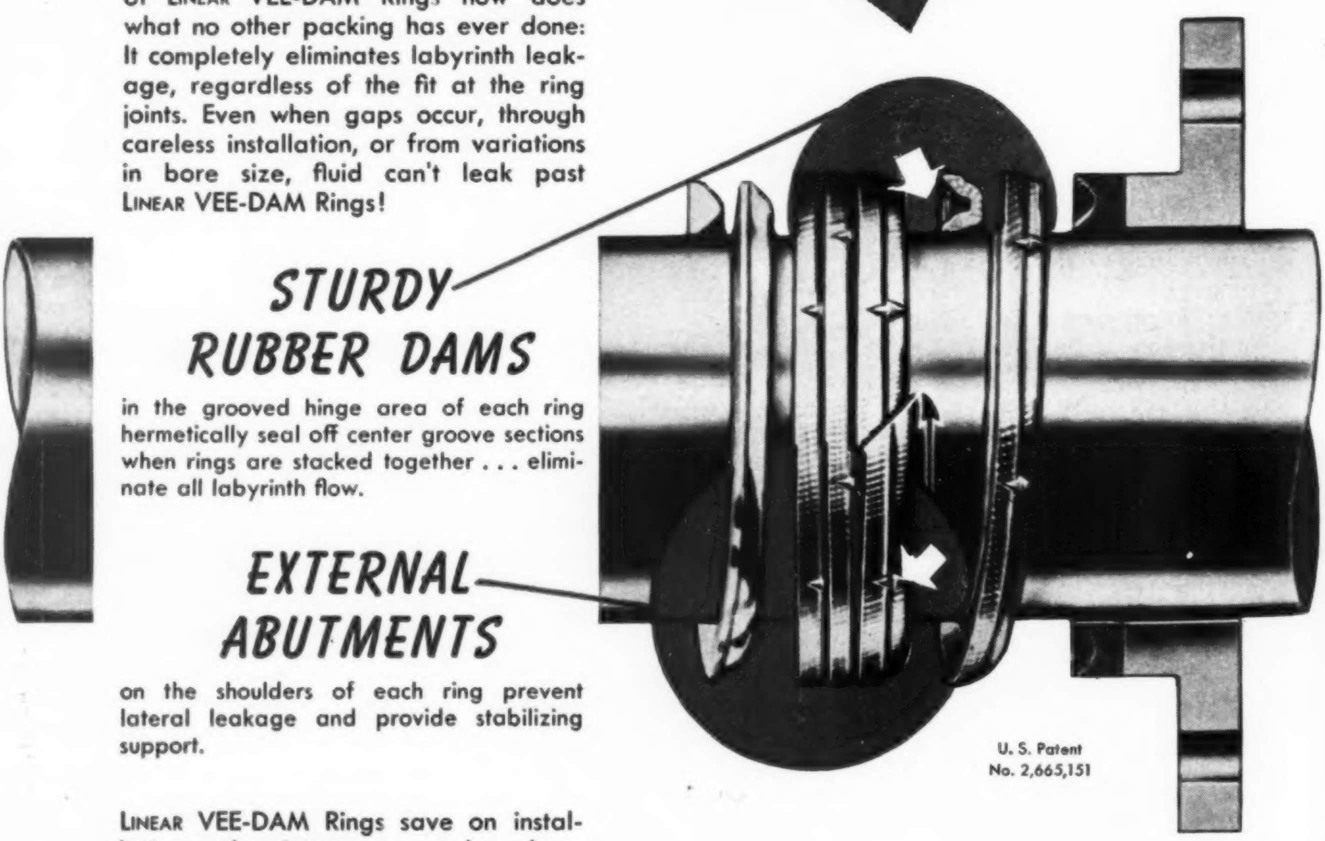
☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE
COMPANY
STREET
CITY ZONE STATE

Here's Terrific NEWS IN HYDRAULIC PACKING!

LINEAR VEE-DAM RINGS

Unique, new and revolutionary design of LINEAR VEE-DAM Rings now does what no other packing has ever done: It completely eliminates labyrinth leakage, regardless of the fit at the ring joints. Even when gaps occur, through careless installation, or from variations in bore size, fluid can't leak past LINEAR VEE-DAM Rings!



STURDY RUBBER DAMS

in the grooved hinge area of each ring hermetically seal off center groove sections when rings are stacked together . . . eliminate all labyrinth flow.

EXTERNAL ABUTMENTS

on the shoulders of each ring prevent lateral leakage and provide stabilizing support.

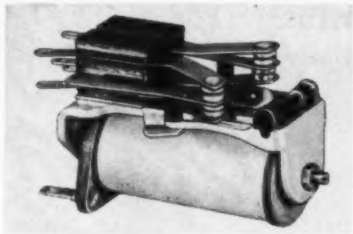
U. S. Patent No. 2,665,151

LINEAR VEE-DAM Rings save on installation and maintenance . . . reduce down time. They last longer, work better! We're molding them in a variety of sizes and compounds. Let us show you how VEE-DAM Rings can solve your packing problems!

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

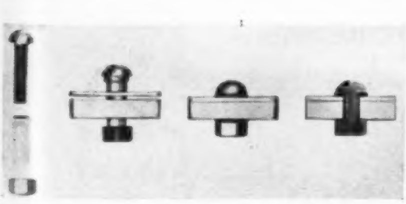


large bearing surface which turns in precisely reamed bearings of nonferrous metal. Under test, relay handled inrush currents of 50 amp for 50,000 operations with a rating of 10 amp, 27.5 v dc. It exceeded 500,000 operations on motor load of 6 amp, inrush current of 15 amp, at 70,000 ft altitude. Nominal rating of the relay is 10 amp, 115 v ac (resistive); 10 amp, 27.5 v dc. Made by **C. P. Clare & Co.,** 4101 W. Pratt Blvd., Chicago 45, Ill.

For more data circle MD-99, Page 241

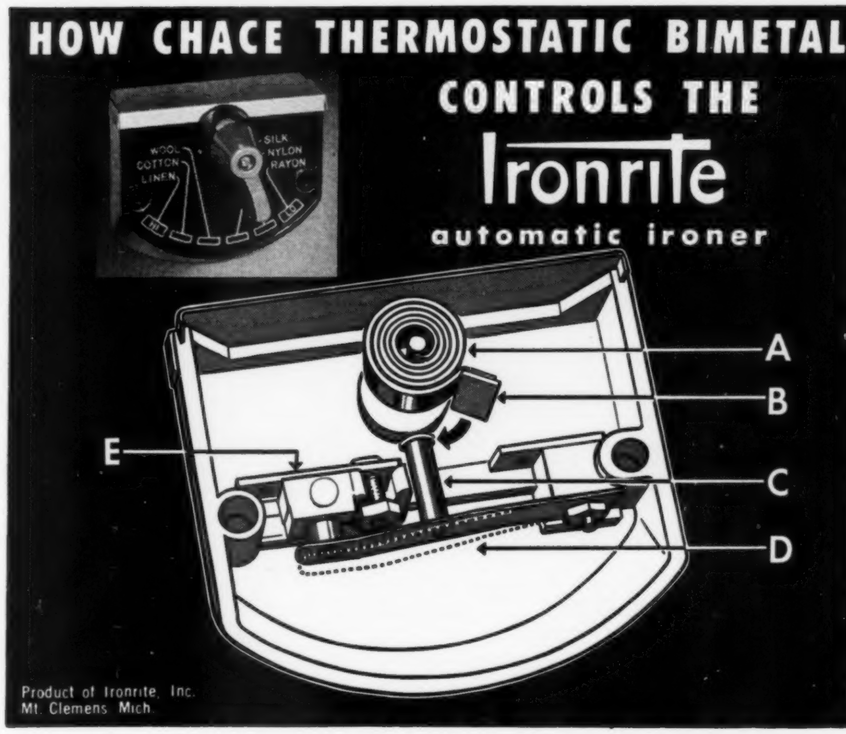
Fastener Sleeve

Used with bolts, screws and rivets, this nylon sleeve reduces failure due to vibration, eliminates electrolytic corrosion, and provides a leakproof seal. Nyltite sleeve utilizes cold-flow properties of nylon to fasten and seal. A short sleeve forms a nylon washer under the head of a bolt, screw or rivet. Another application is as



a compressible sleeve which insulates bolt and nut from work material while serving as lock washer and seal. Extending from bolt head to nut, sleeve is made with a rim flange at one end and is either slipped over the bolt or dropped into the bolt hole. As the nut is drawn up on the bolt, the nylon is compressed and cold flows, forming a washer-like disk at both ends. Nylon also flows solidly around the threads of the

(Continued on Page 282)



Ironrite Automatic Ironers are designed from a functional as well as an aesthetic viewpoint, their chief advantage being speedy, efficient ironing of all materials in almost any shape or form. Simplicity of operation and control are some of the Ironrite Automatic Ironer's foremost features. Of course, for safe, foolproof regulation of temperatures for ironing different fabrics, the Ironrite depends upon Chace Thermostatic Bimetal.

The control switch shown in the illustration is simply, quickly set for temperature variations by moving the indicator to the correct temperature shown for various materials. Whenever the ambient temperature attains the maximum, things begin to happen. A coil of Chace Thermostatic Bimetal (A) rotates, forcing plate (B) against post (C). This leverage bends the circuit connector (D), breaking the circuit at (E) until the ambient temperature is lowered. When the indicator is set for low temperatures, the coil is adjacent to the post and has less distance to move to break the circuit. At high temperature settings the coil is at its extreme distance from the post and requires a greater amount of heat to break the circuit.

Chace Thermostatic Bimetal is available in 29 different types, in strip, rolls or in completely fabricated assemblies made to your specifications. Before development of your new controlling, indicating or protecting device, read our booklet "Successful Applications of Chace Thermostatic Bimetal." Write for your free copy of this valuable engineering data today.

IT BENDS WITH THE HEAT

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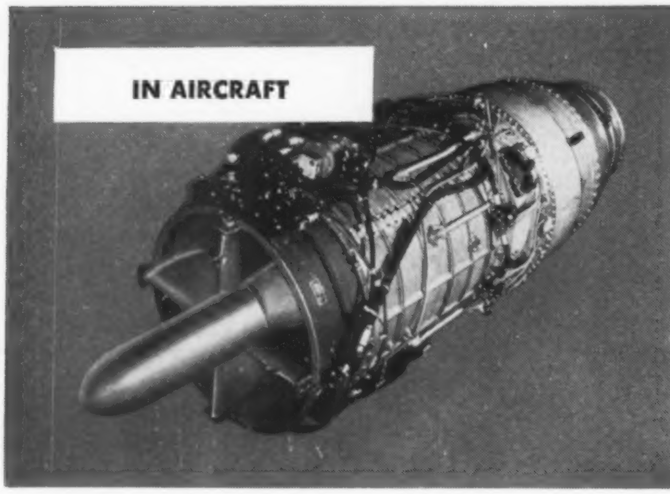
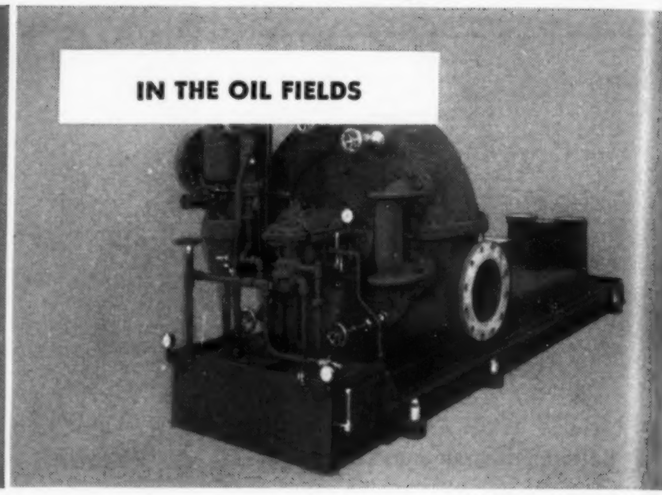
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.



AHEAD OF THE VAPOR TRAIL . . .

CIRCLE Ⓛ Stainless Steel Castings, used for turbine shrouds, heat shield supports and other important parts of turbo-jet engines, withstand temperatures of approximately 1500° F.



IN GIANT NATURAL GAS TURBINES . . .

CIRCLE Ⓛ Stainless Steel Castings were selected to withstand the terrific heat and pressures needed in powering heavy-duty oil pumps delivering thousands of barrels of oil a day.

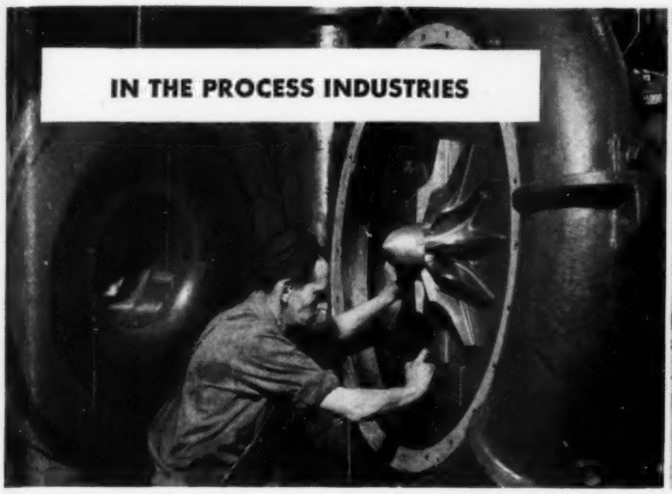
UNIQUE STEEL CASTINGS ARE COMMONPLACE AT LEBANON

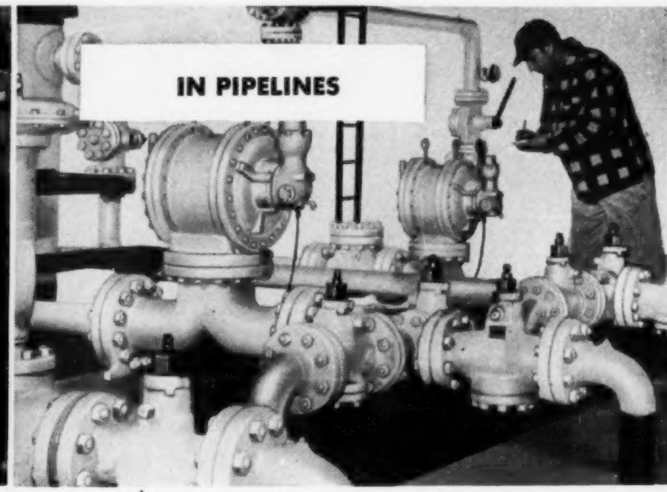
THE HEART OF GIANT TUBE REDUCING MACHINES . . .

CIRCLE Ⓛ Steel Castings are at work in immense oil hydraulic high-pressure pumps . . . operating efficiently at pressures up to 3,000 p.s.i. in huge tube reducing machinery.

IN NEW SHELL MOLDING PROCESS . . .

Lebanon Steel Foundry research is continually developing new processes to improve the performance and economy of CIRCLE Ⓛ Castings. Such research has led to the use of the shell molding process to meet certain customer specifications.





AT THE CENTER OF A MINIATURE TORNADO . . .

CIRCLE Ⓛ Steel Castings for the one-piece, open type, radial bladed impellers are the "tornado blowers" in single-stage centrifugal blowers that are widely used in the process industries.

COUNTING THROUGHPUT OF THESE LIFELINES . . .

CIRCLE Ⓛ Steel Castings form valve bodies for the huge meters that count the billions of barrels of oil flowing through many of the country's pipelines.

Whatever the specification . . . whatever the size . . . from castings weighing only a few ounces to giants of several tons . . . Lebanon Steel Foundry CIRCLE Ⓛ Castings are made to the highest standards of excellence.

CIRCLE Ⓛ CASTINGS CIRCLE THE GLOBE!

NEW LEBANON BROCHURE

Lebanon Steel Foundry has just released a 32-page technical brochure on the operations and technical facilities available. Send today for your copy of this interesting, fully illustrated Lebanon CIRCLE Ⓛ brochure.

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64 Lehman St., Lebanon, Pa.
Please send me a copy of your new *Technical Brochure.*

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LEBANON

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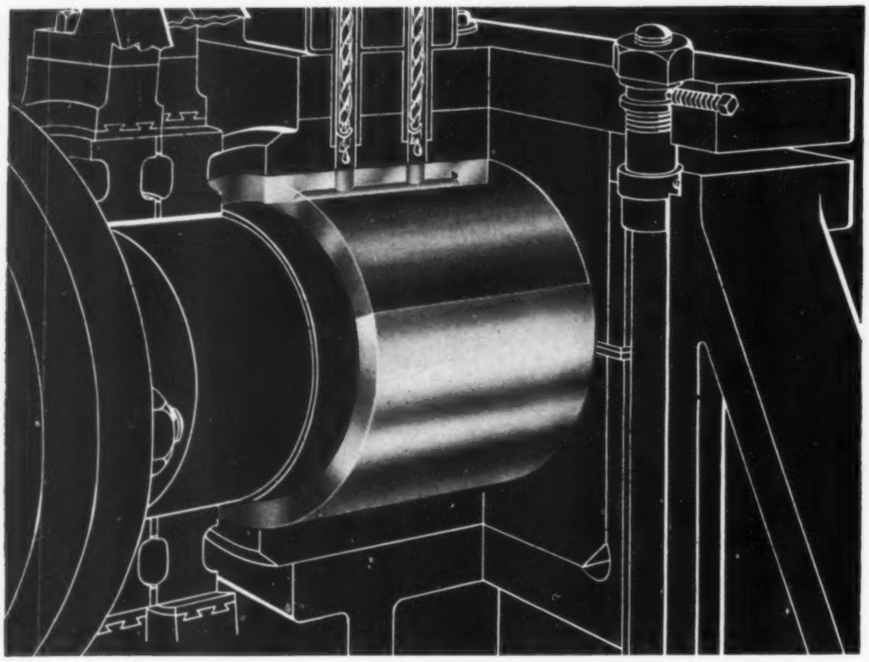
CIRCLE L ® T.M. REG.



THE WAY TO CUT...

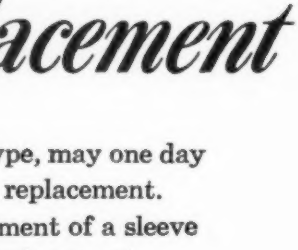
Cost of replacement

Any bearing, regardless of type, may one day reach the point where it requires replacement. If this point is reached the replacement of a sleeve bearing is far less costly than the replacement of any other type of bearing.

Disassembly and removal of the original bearing, installation and reassembly with the new bearing are simpler, quicker and therefore less costly and the cost of the sleeve bearing itself is moderate compared to the cost of other types.

The user of equipment which you design and build will appreciate these advantages of a sleeve bearing.

There is a Bunting Engineer near you. Consult him. Or write our Product Engineering Department at Toledo.



Bunting®

BRONZE BEARINGS • BUSHINGS • PRECISION BRONZE BARS

The Bunting Brass & Bronze Company • Toledo 1, Ohio

Branches in Principal Cities • Distributors Everywhere

New Parts

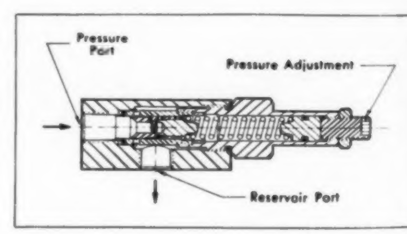
(*Continued from Page* 279)

bolt to provide a positive seal between bolt and bolt hole. The slight tendency of Nyltite to resume its original shape provides sufficient pressure against the bolt head and nut to function as a lock washer. Insulation of bolt and nut from the work material prevents electrolytic corrosion. The leakproof seal withstands temperatures up to 250 F. Nyltite is available in almost any diameter, length and wall thickness to suit specific requirements. Made by **Keystone Plastics Inc.,** 2331 Morris Ave., Union, N. J.

For more data circle MD-100, Page 241

Hydraulic Relief Valve

Used to control pressure in clamping or feed circuits, this spring-loaded, guided piston type relief valve is recommended for circuits where pressure is controlled by continuous flow through

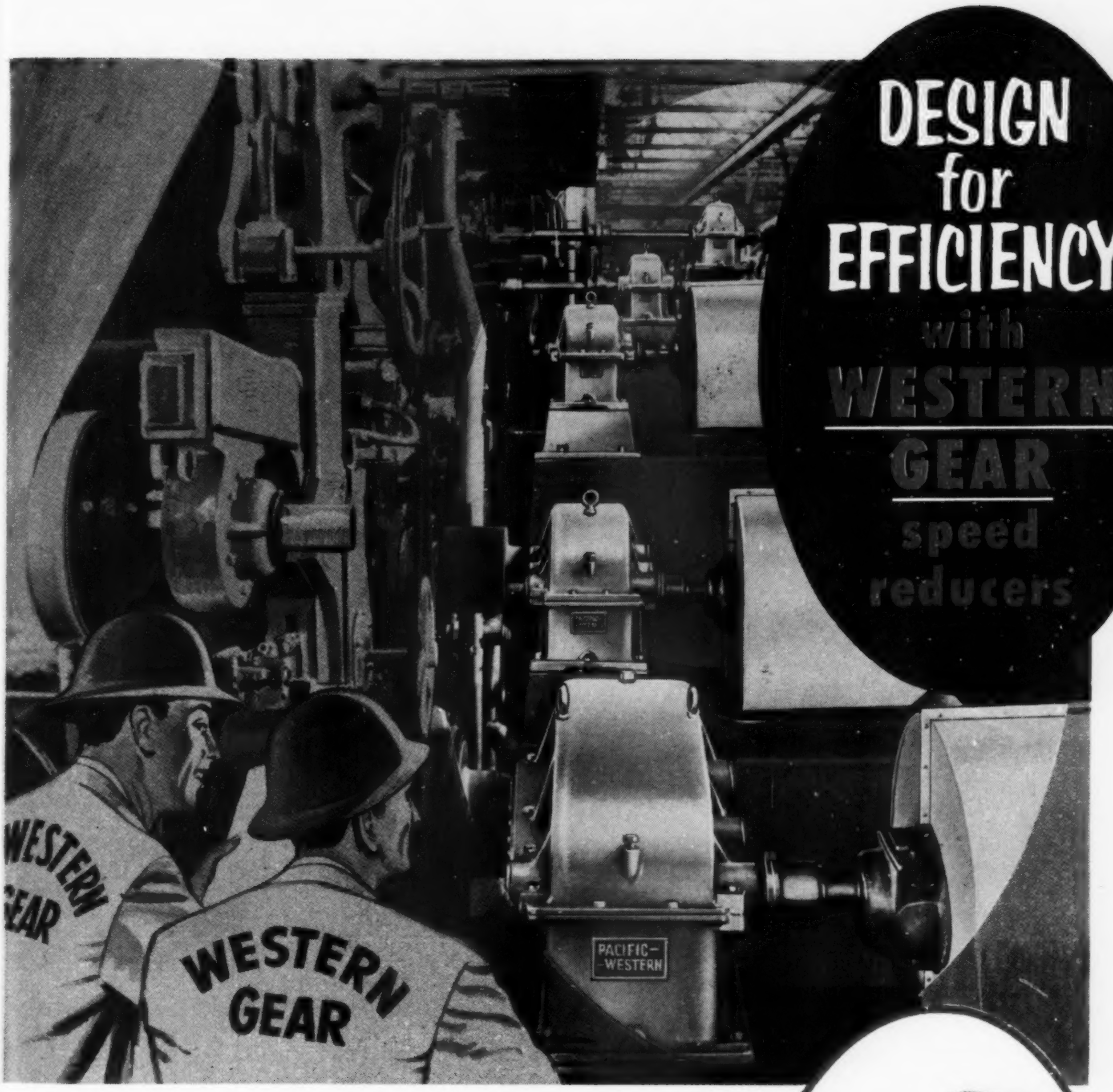


the relief valves. Models are available in $\frac{1}{4}$ and $\frac{3}{8}$-in. sizes, with standard, screw or hand knob pressure adjustment in seven different ranges. These extend from 10 to 30 psi to 200 to 600 psi. Working parts are hardened steel and are ground to fine finish and close tolerance. Made by **Fluid Controls Inc.,** 1284 N. Center St., Mentor, O.

For more data circle MD-101, Page 241

Tachometer Generator

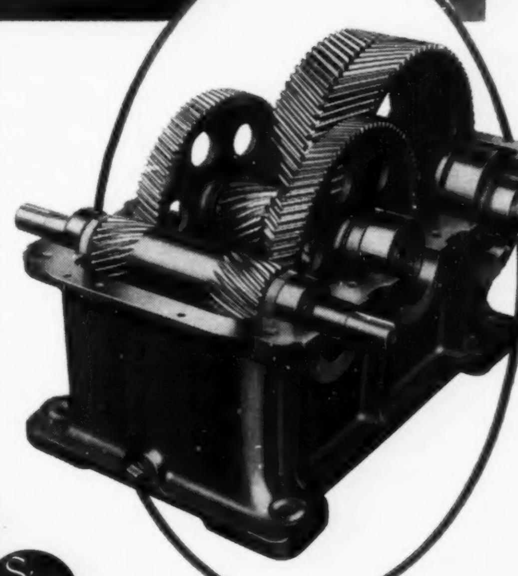
High-voltage dc tachometer generator, designed for a variety of control applications, as well as for accurate speed indications, provides high voltage output of 50 v per 1000 rpm for speeds up to 5000 rpm or 100 v per 1000 rpm for speeds up to 2500 rpm. It can be



If your problem is to increase production and efficiency, and lower operating costs of plant machinery, let Western Gear engineers provide the answer. And if you are replacing outmoded equipment or designing a new plant, your mechanical power transmission problems can be solved to your advantage by Western Gear.

Whether your equipment problem is the proper selection of a speed reducer or the complete design and construction of special machinery, it is one which, by all odds, will not be new to our engineers. Since 1888 Western Gear mechanical power transmission equipment has been a symbol of complete dependability.

Why not call our nearest plant or office now for engineering assistance on a no-obligation basis? Or, if you choose, write Executive Offices, Western Gear Works, P.O. Box 182, Lynwood, California.



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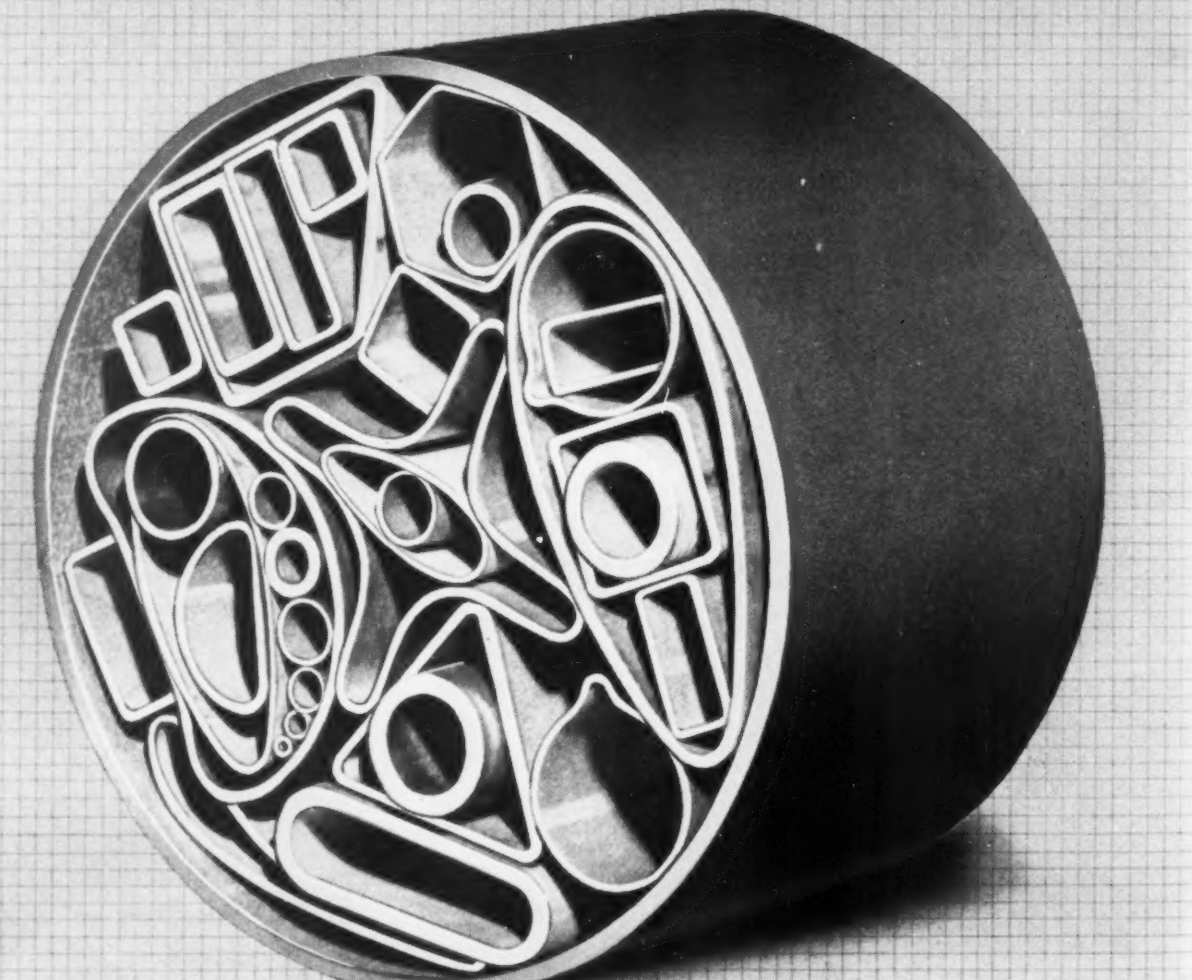
34 design ideas in Stainless Tubing from *Carpenter*



Your immediate problem may be a structural part for a machine, a component for an appliance, an architectural application to combine function with decorative value—but whatever it may be, there's an idea here for you.

You know about stainless; its excellent strength-for-weight ratio, its fine appearance, its stout resistance to corrosion and abrasion. You may not, however, know about special shapes of Carpenter Stainless Tubing and the fine opportunity they offer for real savings in translation of design to finished parts.

Carpenter offers *scores of stainless tubing shapes* in a wide range of dimensions, analyses and finishes as standard production. From them you may be able to select one that will do the job you have in mind. If, however, a "special" is required, *Carpenter can produce it* in any desired quantity—almost any type of finish.

Why not find out more about Carpenter Stainless Shaped Tubing and its possible place in your product designs. Call your nearest Carpenter distributor or branch office for "in-shop" consultation, or write direct to . . .

MEMBER FORMED STEEL TUBE INSTITUTE

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

more than corrosion resistance

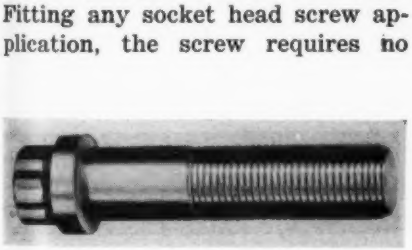
Stainless Tubing & Pipe

used as a pilot exciter for many control applications. Unit is totally enclosed and can be either flange or foot-mounted to be driven by direct coupling, gear or belt. It can be mounted horizontally or vertically. Made by Instrument Dept., **General Electric Co.,** Schenectady 5, N. Y.

For more data circle MD-102, Page 241

Socket Type Screw

Countr-Bor screw is designed for external wrenching to provide flush fit in standard counterbored holes. Fitting any socket head screw application, the screw requires no



special hexagon key. External wrenching with a standard 12-point socket wrench, combined with large wrenching area, result in high wrenching torque. Made by **Ferry Cap & Set Screw Co.,** 2151 Scranton Rd., Cleveland 13, O.

For more data circle MD-103, Page 241

Shut-Off Coupling

Small, quick-connect, one-way shut-off coupling is capable of effectively handling large volumes of air. Series 3-RL Ring-Lock coupling for pressure and vacuum applications has completely interchangeable sockets and plugs and will handle any air line and many

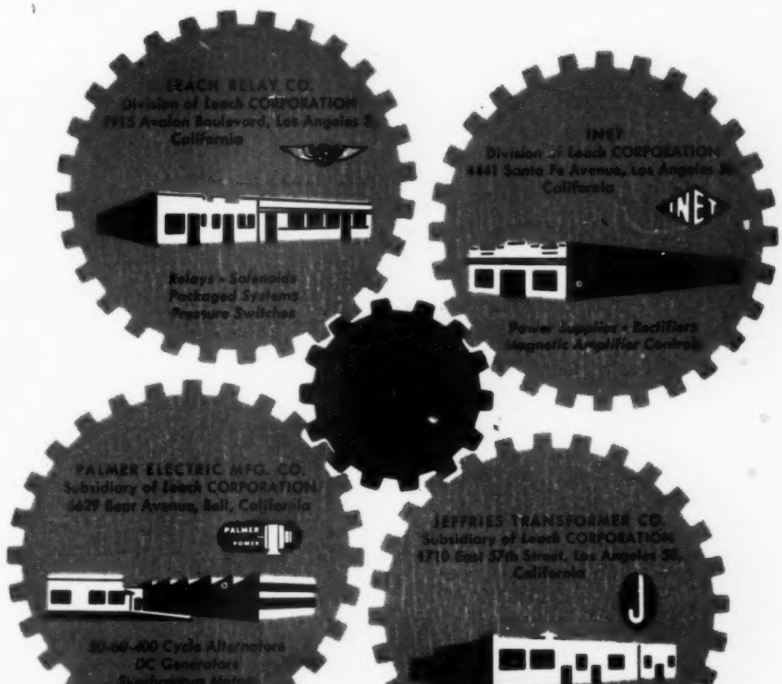
(*Continued on Page* 288)

Leach CORPORATION

4 *Divisions*

Geared to Mesh

...FOR CUSTOMER SATISFACTION



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4 individual, electrical companies geared to mesh for *efficient, economical* operations . . . modern production facilities, outstanding scientific and engineering talent co-ordinated by a stable corporate organization to benefit the customer as well as the industries which they serve. *Customer satisfaction* is the prime consideration that governs policy and practice at *Leach.*

These companies are all pioneers in electrical progress with a total background of more than 100 years of leadership in designing and manufacturing precision equipment for aircraft, commercial and industrial applications . . . proud of the many advancements their products have made possible in the field of electrical, electronics, electro-mechanical systems, communications and instrumentation.

For aircraft, commercial and industrial efficiency and safety . . . *Leach* has become *The Most Trusted Name in Specialized Electrical Equipment.*

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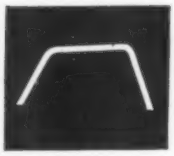
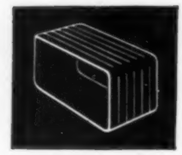
Design
Production

Leach CORPORATION
5915 Avalon Blvd., Los Angeles 3, Calif.
District Offices and Representatives in Principal Cities of U.S. and Canada



AUTOMOTIVE

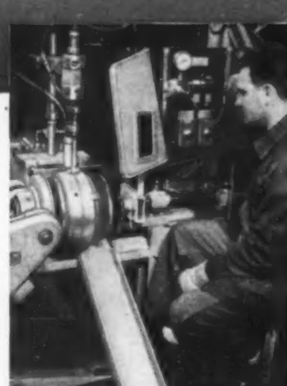
The automotive company buying these door frames from Reynolds gets a combined structural and trim part ready for assembly and on model design changes saves large tooling costs on the door and components.



APPLIANCE

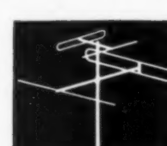
Reynolds now produces evaporators and over a dozen other parts for the refrigeration and air conditioning industry. They also produce washer and dryer tubs and many parts for electrical ranges.

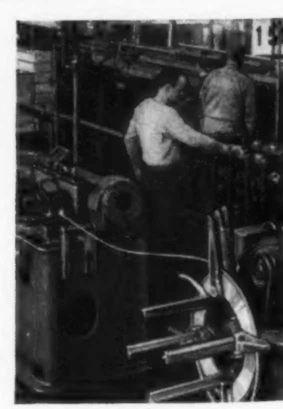
America's leading industries buy aluminum parts fabricated by Reynolds



TRUCK AND TRAILER

Reynolds pioneered this field. Now, some of the leading companies in this industry have found that Reynolds presses and automatic welding equipment can produce trailer parts and prop wheels more economically and efficiently than anyone else.





ANTENNA

Reynolds is now supplying a new and improved roll formed tubing to the leading producers of TV antennae—and it costs no more than regular tubing previously used.

REYNOLDS ALUMINUM

BLANKING · EMBOSSING · STAMPING · DRAWING · RIVETING · FORMING

MATERIALS HANDLING

The light weight and durability of aluminum, coupled with the fabricating experience of Reynolds, is making the use of aluminum pallets natural for companies who must ship their products on returnable pallets.

...and here's why

ENGINEERING SERVICE

The wide variety of industries served by Reynolds Aluminum Fabricating Service has made our engineering and sales force familiar with problems throughout the metal-working field. These trained salesmen and engineers plus many technical men are available to industry at all times. They will help you re-design your present parts to take advantage of aluminum, help design new parts of aluminum and show you how Reynolds can more efficiently and economically produce your parts for you.

FABRICATING EXPERIENCE

Reynolds Aluminum Fabricating Service has been producing aluminum parts for many different industries for many years. Through this experience has been gained a practically unparalleled knowledge of the fabricating of aluminum parts requiring blanking, embossing, stamping, drawing, riveting, forming, roll shaping, tube and shape bending, welding, brazing and finishing.

VAST DIVERSIFIED FACILITIES

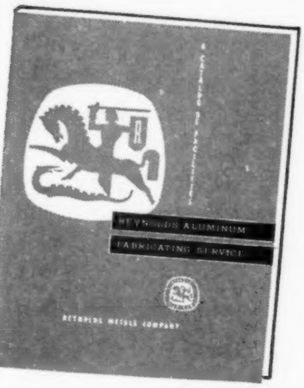
There are over 200 pieces of major equipment in the 2 major parts producing plants of Reynolds. This includes presses from the very smallest up to presses capable of producing drawn parts 12' long. Also included are roll forming machines, some of the most modern aluminum welding equipment in the country and some of the most up-to-date automatic anodizing equipment.

MONEY-SAVING ADVANTAGES

Reynolds parts customers save money many ways. Most important, they do not tie up their capital in raw material inventory and they do not have to buy "specialized" equipment which might be in use only part of the time. Parts from Reynolds Aluminum Fabricating Service are shipped ready to assemble into final products. This also saves on production losses, rejects and scrap handling and storage.

• • •

Write for your copy of the new 24-page "Catalog of Facilities." Get full details on the tremendous production facilities of Reynolds Aluminum Fabricating Service.



The industries covered on these pages are but a few examples of the many now being served by Reynolds Aluminum Fabricating Service. The leaders in these industries have found Reynolds experience and facilities to be valuable assets to their own excellent knowledge and facilities. For full details on how Reynolds can prove of assistance to you, call the Reynolds office listed under "Aluminum" in your classified telephone directory or write Reynolds Aluminum Fabricating Service, 2061 South Ninth Street, Louisville 1, Kentucky.

See "Mister Peepers", starring Wally Cox, Sundays on NBC-TV

FABRICATING SERVICE

ROLL SHAPING · TUBE BENDING · WELDING · BRAZING · FINISHING

For DEPENDABILITY

ERIE the correct fastener for the job!

Erie Fasteners are in wide use by the nation's leading builders of Industrial Turbines.

You can rely on over 40 years of experience in producing bolts, studs and nuts designed to withstand the effects of high and low temperatures, high stresses, fatigue and corrosion. Modern facilities enable our skilled craftsmen to produce to your specifications bolts, studs and nuts, precision machined and heat treated in carbon, alloy, stainless steel and non ferrous metals.

These Erie Products prove their quality every day in the railroad, chemical, petroleum and automotive industries; on farm, construction and industrial equipment and heavy machinery. Send your design and material specifications to us . . . we will make for you the Correct Fastener for the Job.

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ERIE • PENNSYLVANIA

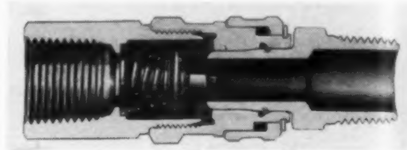
STUDS • BOLTS • NUTS
ALLOYS • STAINLESS
CARBON • BRONZE

Representatives in Principal Cities.

New Parts

(*Continued from Page* 285)

fluid line applications requiring ¾ to ⅛-in. connections. Equipped with an automatic sleeve lock, the coupling is quickly and positively connected by pushing the plug into the socket. Disconnection is accomplished by turning the sleeve.

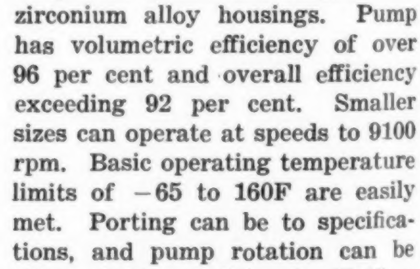


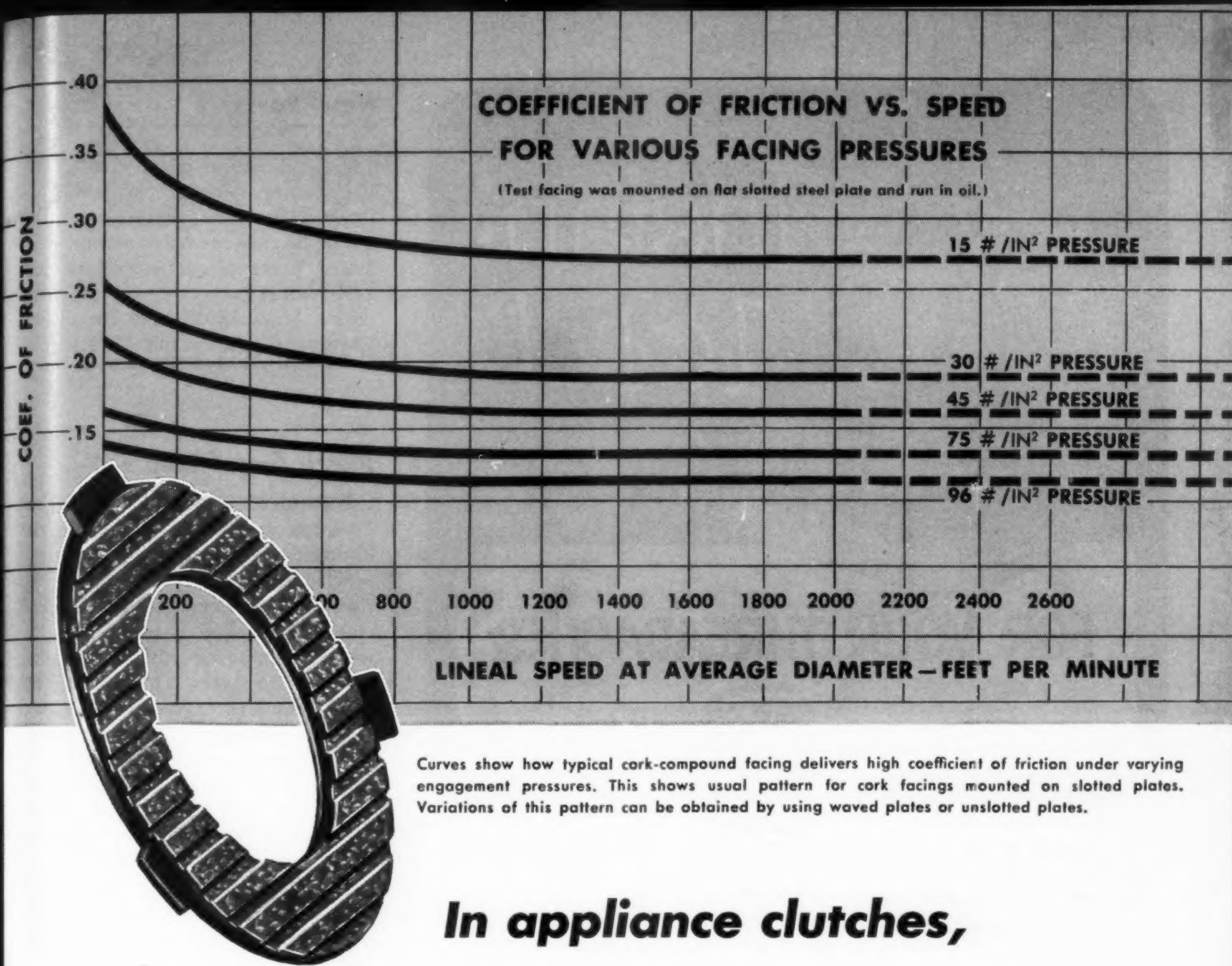
A locking ring in the socket which is forced into a groove in the plug when the coupling is connected provides practically 360-deg metal-to-metal contact, reducing wear and insuring tight fit. Sockets are brass with steel sleeves; plugs are steel. Sockets for use with small hand-operated air tools are available in aluminum. Made by **Hansen Mfg. Co.**, 4031 W. 150th St., Cleveland 11, O.

For more data circle MD-104, Page 241

Hydraulic Pumps

Designed for 3000 psi operation and available in sizes having nominal rated deliveries from 0.60 to 23 gpm at 1500 rpm, line of variable displacement hydraulic pumps for aircraft applications have cast alloy steel yokes and magnesium-zirconium alloy housings. Pump has volumetric efficiency of over 96 per cent and overall efficiency exceeding 92 per cent. Smaller sizes can operate at speeds to 9100 rpm. Basic operating temperature limits of −65 to 160F are easily met. Porting can be to specifications, and pump rotation can be either right or left-hand. Uniflow





Curves show how typical cork-compound facing delivers high coefficient of friction under varying engagement pressures. This shows usual pattern for cork facings mounted on slotted plates. Variations of this pattern can be obtained by using waved plates or unslotted plates.

In appliance clutches, cork facings offer economy and long, trouble-free service

If you're designing appliances that use clutches, you should investigate the unique advantages which cork-compound friction materials offer.

ECONOMY AND LONG SERVICE. Cork's unusually high coefficient of friction, even when immersed in oil, normally makes it possible to use fewer plates, to reduce the plate size, or to lower engagement pressure—and still maintain torque capacity. In such cases, substantial savings can be realized in material, metal, fabrication, and assembly.

Cork facings offer the further economy of long service. In a properly designed wet clutch, there is virtually no wear, and cork facings will last the life of an appliance and still be serviceable.

TROUBLE-FREE PERFORMANCE. Because they are resilient and non-abrasive, cork facings will not score or damage opposing metal plates. No metal particles are freed to damage gears and bearings. Thus, cork facings eliminate a common cause of clutch trouble.

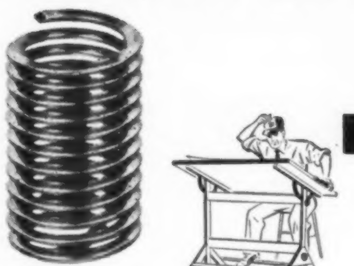
A well-known appliance manufacturer discovered the value of these advantages when he used cork facings in place of metal friction plates. Cork's high torque capacity enabled him to use only three cork facings in place of eight metal friction facings—an important saving in material and labor. But equally important, the cork facings did not release abrasive particles into the oil. As a result, expensive service calls and clutch replacements were virtually eliminated.

Appliances are only one field where cork friction materials are used today. There are many other applications in such fields as automotive and industrial equipment and business machines. Tell us your problem, and we'll gladly help you choose the most efficient cork compound for your clutch. Write Armstrong Cork Co., Industrial Div., 7212 Dean St., Lancaster, Penna.

Armstrong FRICTION MATERIALS

Instant Relief

FOR YOUR THREADACHES



The headaches caused by threaded fastenings — soft materials, corrosion, frequent use—are banished immediately with *Heli-Coil Screw Thread Inserts.**

Thousands of manufacturers have used and proved them. ***Heli-Coil*** Inserts provide much greater loading strength for your threads, make threads so perfect they will never wear, strip, seize, corrode, gall. With ***Heli-Coil*** Inserts you can use fewer, smaller, shorter fastenings and lighter, cheaper materials... this saves you space, weight and MONEY.

Check today on how and why ***Heli-Coil*** Screw Thread Inserts are the answer to the designer's prayer. Just mail the coupon for full information and samples.

***Heli-Coil* Inserts conform to official Military Standards MS-122076 (ASG) through MS-124850 (ASG) and others.**

* Reg. U. S. Pat. Off.

HELI-COIL CORPORATION
132 SHELTER ROCK LANE, DANBURY, CONN.

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☐ Please have a *Heli-Coil* Thread Engineer call.
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(single direction of oil flow) and over-center design (reversing oil flow) types are available. Also available are remote servo controls, pressure actuated control piston and other types of controls. Made by **Vickers Inc.,** 1400 Oakman Blvd., Detroit 32, Mich.

For more data circle MD-105, Page 241

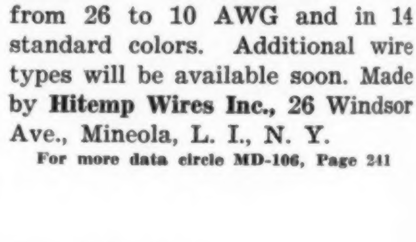
Plastic Coated Wire

Extruded Teflon coating on Temprex stranded hookup wire is intended for high temperature service (class H or better). Insulation is impervious to all commercial solvents and is unaffected by weathering, aging, fungus or moisture. Wire meets requirements of MIL standard 104 and MIL-W-16878A for type E and EE constructions. Ambient temperature range from −90 to 260 F will not change electrical or physical characteristics. Wire is made in sizes from 26 to 10 AWG and in 14 standard colors. Additional wire types will be available soon. Made by **Hitemp Wires Inc.,** 26 Windsor Ave., Mineola, L. I., N. Y.

For more data circle MD-106, Page 241

Four-Way Valve

Two-position, four-way selector valve for use in low-pressure air or hydraulic systems is leakproof at working pressures to 100 psi. It maintains very low handle torque. Standard O-ring seals are used throughout to assure leakproof operation, low friction drag and simple maintenance. Handle stops assure positive alignment of ports. Model S-576 is available in ¼-in. tube size. Valve body is black an-



Do You Get All This...

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...you do when you specify HOUGHTON!

FIRST, because we have every type of packing you need including synthetic rubber, leather and the new Houghton-Developed rubber-impregnated leather packings.

SECOND, every type: Cup, flange, U, V, including O-rings, washers, discs and gaskets . . . for oil, air, water and gas applications for all pressures and for temperature up to 2000°F.

THIRD, we're the only packing manufacturer also supplying all types of hydraulic fluids . . . reinforced petroleum base oils . . . lubricant additives for water systems . . . and the new Houghto-Safe non-flammable hydraulic fluid.

MOREOVER, we give you complete engineering service to match Houghton quality packings and fluids. Ask the Houghton Man about it.

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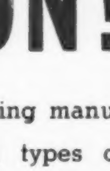


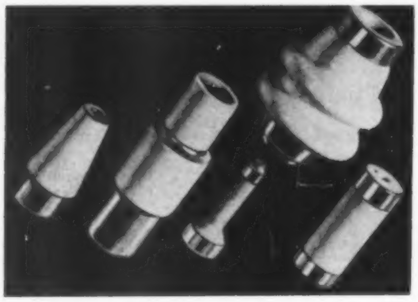
Ready to give you on-the-job service . . .

odized, cast aluminum. Valve may be disassembled without disconnecting system lines. Made by **Sprague Engineering Corp.**, 1144 W. 135th St., Gardena, Calif.

For more data circle MD-107, Page 241

Metal-to-Ceramic Coating

Both hard and soft solder will bond to new metallic coating developed for application to either

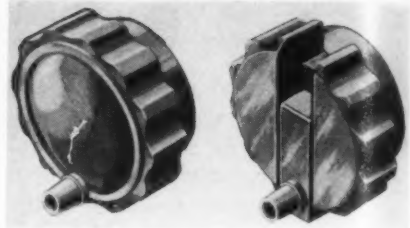


glazed or bisque refractory ceramic bodies. Solder may be applied to form vacuum-tight joints with metal parts or other nonmetallic refractories. Use of a single coating eliminates the need for intermediate plating treatments. Hard solders which melt in the range of 1000 to 1600 F and soft solders melting at temperatures from 245 to 450 F may be applied directly to the metal coating. Process is employed in the manufacture of mechanical, electrical and electronic seals; tube socket bases, switch stators and rotors, capacitor rotors and shafts; terminals; coil forms and similar components. Made by **Frenchtown Porcelain Co.**, 88 Muirhead Ave., Trenton, N. J.

For more data circle MD-108, Page 241

Instrument Knobs

Controlled torque knobs are designed to safeguard delicate instruments against careless or inadvertent cranking beyond their normal stops. Knobs work on slip-clutch principle, automatically disengaging and slipping when a predetermined torque is exceeded. They are fluted to aid in sensi-



tive adjustment and have spinners for rapid setting. For use on standard 1/4-in. shafts, knobs measure 1 7/8 in. OD x 15/16-in. thick. They are available with nonretractable and retractable spinners, the latter being useful for equipment which must fit into small space or which is in danger of accidental movement of protruding controls. Knobs are also available without the slip clutch. Made by **Jan Hardware Mfg. Co. Inc.**, 75 N. Eleventh St., Brooklyn 11, N. Y.

For more data circle MD-109, Page 241

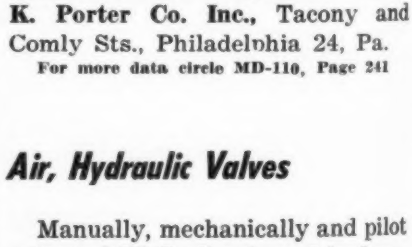
Flexible Plastic Pipe

Series 200 lightweight, flexible polyethylene pipe will not rot, rust or corrode. It is nontoxic, easily handled, and requires no special tools for installation. Pipe is available in all popular sizes. Made by Quaker Rubber Corp., Div. of **H. K. Porter Co. Inc.**, Tacony and Comly Sts., Philadelphia 24, Pa.

For more data circle MD-110, Page 241

Air, Hydraulic Valves

Manually, mechanically and pilot actuated Hi-Cyclic air and hydraulic valves are available with interchangeable actuators such as hand lever, fingertip, foot lever, piloted

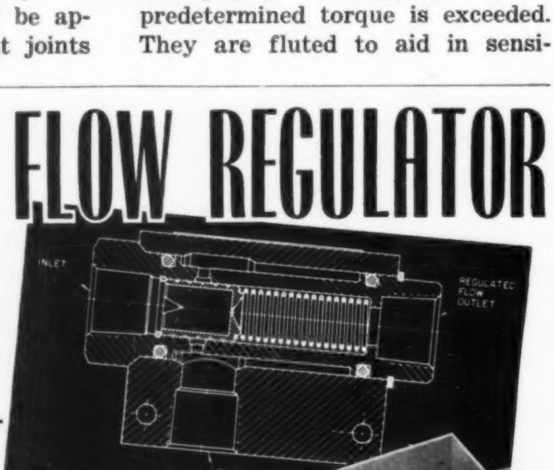


and cam roller. Snap-on construction facilitates change from one type actuation to another. Solenoid control is also available. Mounting brackets and actuators can be

CONSTANT FLOW REGULATOR

with

Automatic BY-PASS



It's another WATERMAN FLOW CONTROL VALVE for—

- Power Steering Systems
- Fluid Motors
- Secondary Circuits
- Or any Hydraulic Circuit where a Constant Flow Rate is required from a Variable Volume Pump Output.

BY-PASS FLOW REGULATORS relieve excess flow at working pressure resulting in—

- Reduced Oil Temperatures
- Increased Efficiency
- Less Maintenance

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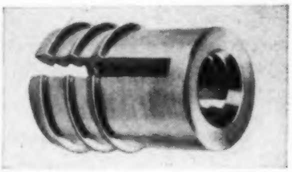
rotated 90, 180 or 270 deg for mounting and operating valve in any position. Types are available with 1/8, 1/4, 3/8 and 1/2-in. NPT ports for air, and with 1/8, 1/4 and 3/8-in. NPT ports for oil and water hydraulics. Made by **Beckett-Harcum Co.,** Wayne Rd., Wilmington, O.

For more data circle MD-111, Page 241

Heavy-Duty Inserts

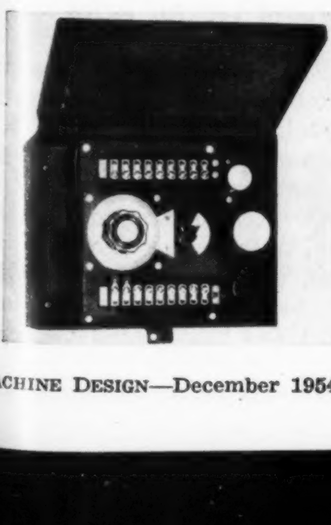
Redesigned series N31 lightweight, heavy-duty inserts provide reusable, self-locking threads in blind holes. Incorporation of three sharp fins instead of two blunt fins affords easier penetration and provides equal holding power with less locking torque or more holding power with the same torque. Applicable to heavy-duty uses, insert is 9/16-in. long and is available for screw sizes from 8/32 to 3/8-16. Application is effected by driving the insert into a plain round hole then entering the screw which locks the insert in position. Made by Banc-lok Div., **Boots Aircraft Nut Corp.,** Newtown Turnpike, Norwalk, Conn.



For more data circle MD-112, Page 241

Electronic Timer

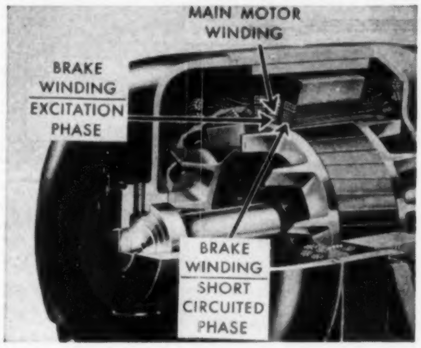
Interval, delay, repeat cycling, programming or pulsing timing functions are performed by the model T2 electronic timer. This control timer is particularly suited for use on process timing and sequence control of automated equipment, induction heaters, machine tools, molding machines and packaging and filling machinery. Accuracy within 1 per cent is maintained over line voltage variations of 90 to 135 v. Time ranges of 0.1-1, 1-10 and 10-100 seconds, direct-reading time dial and two single-pole, double-throw load contacts with 8-amp rating are incorporated. Made by **Ferrara Inc., Dept. C-5, 8106 W. Nine** Mile Rd., Oak Park 37, Mich.



For more data circle MD-113, Page 241

Dynamic Brake Motor

Compact dynamic brake is built into standard frame size single or polyphase ac induction motors. The multi-polar, two-phase brake winding is superimposed on the standard stator winding. One phase of the brake winding is connected to a single phase line during braking operation; the second phase is permanently short-circuited and is never connected to the line. Unit has no moving parts. It is currently available on motors up to 30 hp; larger sizes will be developed. Made by **Master Electric Co.,** 126-33 Davis Ave., Dayton, O.



For more data circle MD-114, Page 241

Protective Coating

Corrosive action between paint and aluminum alloys is inhibited by Proseal No. 16, a chromate conversion protective coating. Product is suitable for production

GENERATED HELICAL ROD

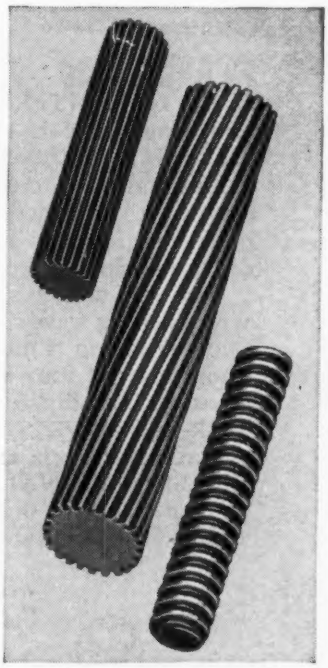
Mass Gear can generate spur, helical and worm pinion rod in all types of material including plastic.

Mass Gear can also produce any type of serrated or special form rod that can be generated.

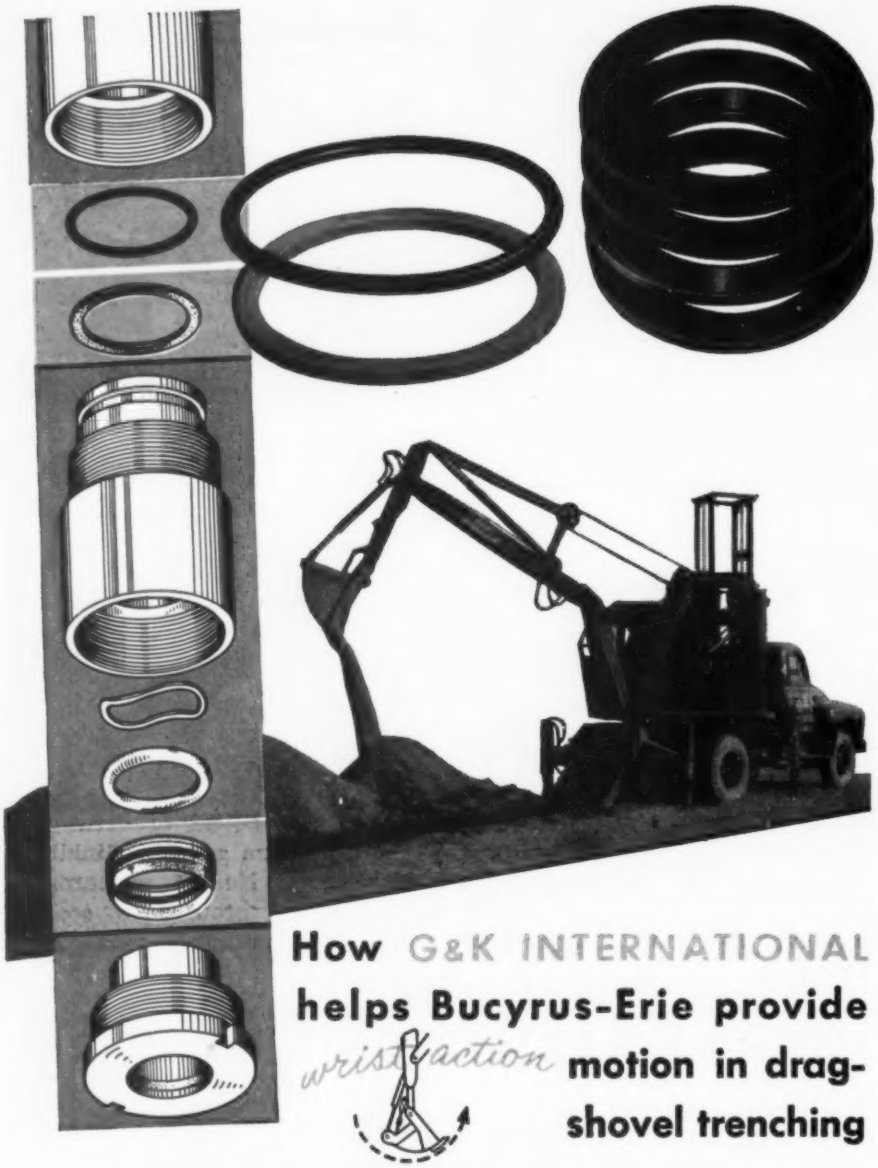
These rods are available up to 6 feet in length, from 5/32" to 1 1/4" in diameter.

Mass Gear products are made to A.G.M.A. standards, thus insuring uniform quality.

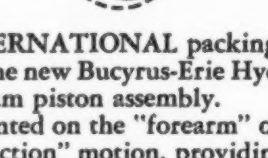
Illustrated brochure showing interesting designs and suggestions available upon request.



Massachusetts Gear & Tool Co.
WOBURN, MASS.



How G&K INTERNATIONAL helps Bucyrus-Erie provide



motion in drag-shovel trenching

Twelve G&K-INTERNATIONAL packings are installed in the dipper tilting ram of the new Bucyrus-Erie Hydrohoe: five in the housing and seven in the ram piston assembly.

This ram is mounted on the "forearm" of the Hydrohoe, and gives the dipper "wrist action" motion, providing a secondary and shorter radial digging arc. The ram must extend and retract, and respond to "finger-tip" control.

Two sets of one synthetic rubber and three leather V-packings with packing wave springs are opposed on the ram piston assembly, and an O-Ring is used as a static seal. In the housing (illustrated), another set of four V's prevents leakage around the shaft, and the housing assembly is made fluid-tight by a static O-Ring seal with back-up washer.

Packings such as these, precision-manufactured by G&K-INTERNATIONAL, provide the design engineer with standard and special types in leather or synthetic rubber to meet all requirements in hydraulic and pneumatic power applications.

Write for G&K-INTERNATIONAL Catalog and Manual 201-A. 60 pages of up-to-date data including latest JIC and officially recommended sizes for all types of packings.

G&K-INTERNATIONAL Packings

GRATON AND KNIGHT

LEATHER — SYNTHETIC RUBBER

GRATON & KNIGHT COMPANY, Worcester, Massachusetts
INTERNATIONAL PACKINGS CORPORATION, Bristol, N. H.

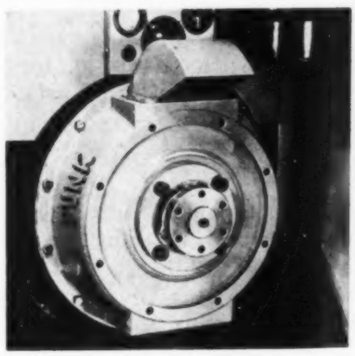
P-6

coating of extruded, forged, wrought or cast aluminum. In tests, no physical property changes were noted on panels treated with the coating after 500 hours exposure to 20 per cent salt spray solution at 95 F. Coating provides a deposit of high percentage of insoluble, trivalent chrome—as opposed to lower concentration of soluble, hexavalent chrome. Developed by Promat Div., **Poor & Co.,** 851 Market St., Waukegan, Ill.

For more data circle MD-115, Page 241

Torque Converter

Model C-20 is an extremely short-coupled torque converter designed for use where space is limited. It is available either ventilated or nonventilated. The main body is a one-piece steel casting, machined

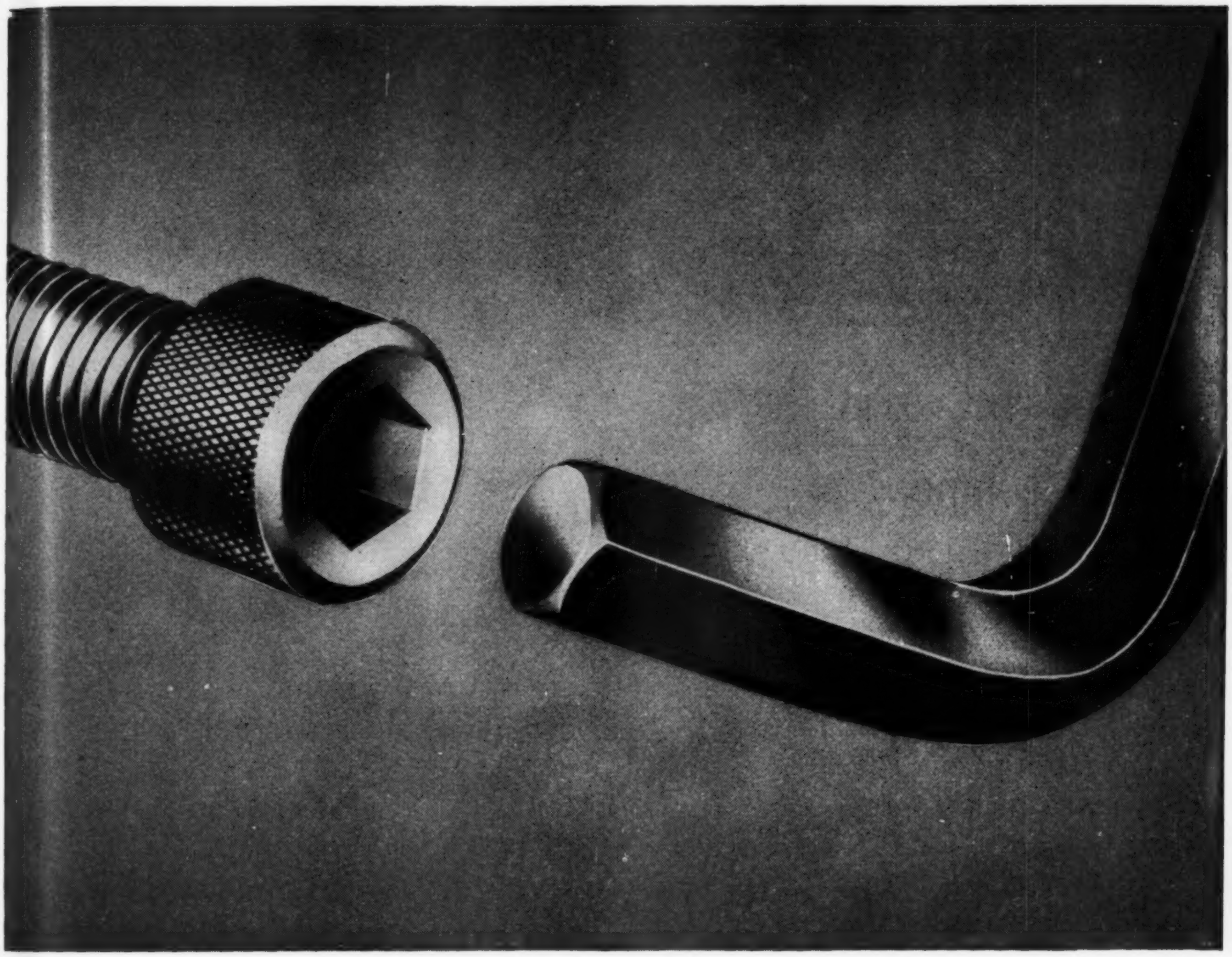


to fit engines with SAE flywheel housings. Standard outside flanges facilitate attachment to right-angle drives, transmissions, gear reducers, power take-off hubs or other types of drives. Made by **Funk Aircraft Co.,** Coffeyville, Kans.

For more data circle MD-116, Page 241

Hydraulic Control Valve

Model 1260 four-way control valve is designed for double-acting hydraulic cylinders. Valve is a pressure-balanced, sliding spool type and has a built-in adjustable relief valve. It is a three-position valve with open center spool, spring return to neutral. Spool is hardened, ground and chrome plated. The handle can be mounted



Bristol Hex Socket Cap Screws assure speedier, easier, tighter fastening

Bristol hex socket cap screws meet every production and maintenance requirement.

They spin easily into place, fit perfectly, and wrench up tightly, even in hard-to-get-at places. They take the wrench without skidding, too, so there's no danger of marring surfaces. Disassembly is just as easy. And Bristol's hex socket screws can be tightened far beyond the point where shock or vibration will loosen them.

This extra holding power results from the hex socket design, and Bristol's careful control over materials and manufacturing methods. Standard hex socket cap screws are made of alloy steel specially hardened. Other special metals and finishes may also be supplied. All Bristol screws are A.S.A. approved and precision threaded either National Coarse or National Fine.

Ask for Bristol hex socket cap or set screws in sizes from 0 wire to one inch in diameter at your industrial distributor's.

BRISTOL'S SOCKET SCREWS

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

AIR CONDITIONERS

FANS OIL BURNERS WASHING MACHINES

IRONING MACHINES FURNACE BLOWERS

EVAPORATIVE COOLERS OFFICES MACHINES PHONOGRAPHS

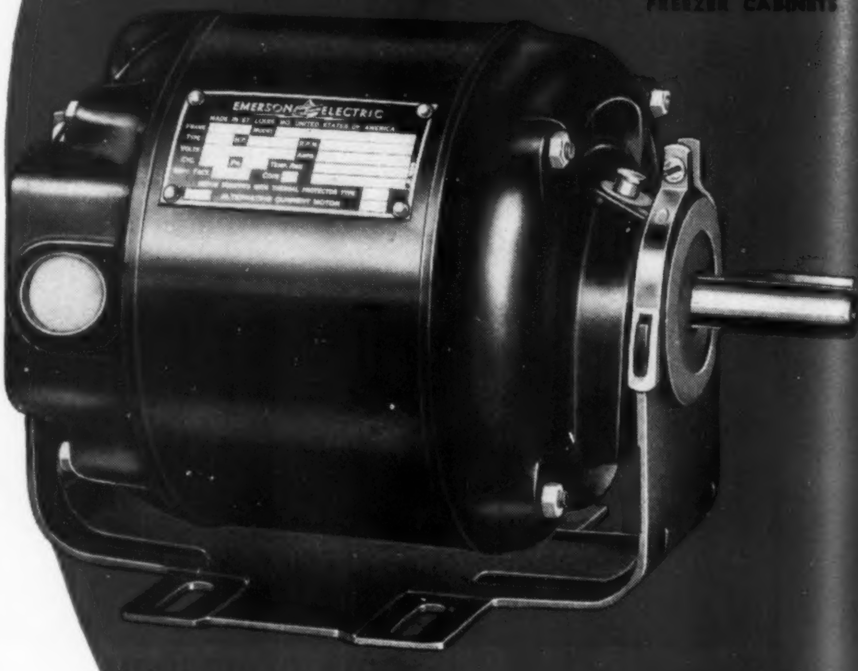
VENDING MACHINES HOME WORKSHOP TOOLS PUMPS

STOKERS UNIT HEATERS REFRIGERATORS

FREEZER CABINETS

AT THE VERY HEART OF FINE REPUTATIONS..

AN EMERSON ELECTRIC MOTOR

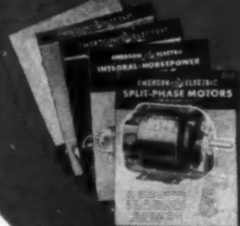


The valuable extra you get with your Emerson-Electric motor

You probably know that the Emerson-Electric motor has helped to build more than one product reputation by its outstanding performance.

But are you aware that you can take advantage of the specialized experience and technical skill of Emerson-Electric Engineers and Designers on anything related to electric motors?

Often, a simple change in design or production technique can save you many dollars, deliver better performance for you. Remember, Emerson-Electric has specialists ready to help solve your most complex motor problems.

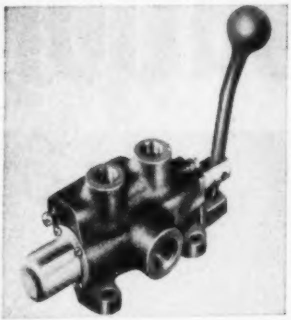


Write for information on this consulting service, or bulletins on Emerson-Electric's complete line of NEMA standard motors from 1/20 to 5 h. p. (Check Bulletin desired.)

- ☐ M458-A Capacitor-Start
- ☐ M458-B Split-Phase
- ☐ M458-C Integral
- ☐ M458-D Fan Duty
- ☐ M458-E Oil-Burner
- ☐ M458-F Jet Pump
- ☐ M458-G Blower

THE EMERSON ELECTRIC MANUFACTURING CO.
St. Louis 21, Mo.

EMERSON ELECTRIC
MOTORS • FANS APPLIANCES

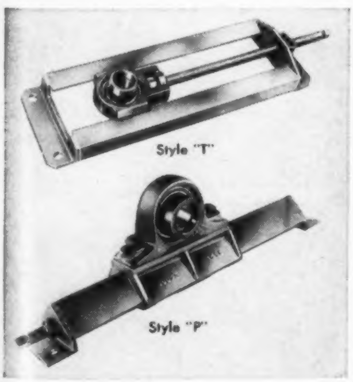


in any of four positions. Factory set at 1000 psi, valve is adjustable from 750 to 1500 psi. It is suitable for operating hydraulic loaders, dumps, push-offs and industrial hydraulic equipment and can be used as a single unit or mounted in series for multiple control purposes on all types of hydraulically actuated equipment. Made by **Dukes Co. Inc.,** 2108 N. Southport Ave., Chicago, Ill.

For more data circle MD-117, Page 241

Take-up Bearings

Two new self-aligning take-up bearings, made of welded structural steel, can be loaded in tension or compression. Style "T" is designed for wall mounting; style "P" is of protected screw design for horizontal application. Both



bearing units are permanently lubricated and are equipped with standard 200 series MRC ball bearings with wide inner ring and deep ball race groove. Ball bearings are close curvature type, providing maximum load-carrying capacity without sacrifice of radial space for shaft adapter sleeve.

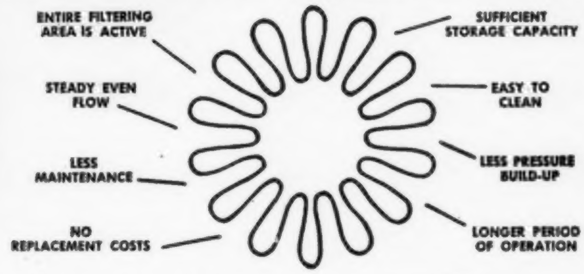
(*Continued on Page* 302)

When You Need A Filter— Get The Advantages of MARVEL'S SYNCLINAL. DESIGN

It's Balanced For Top Performance!

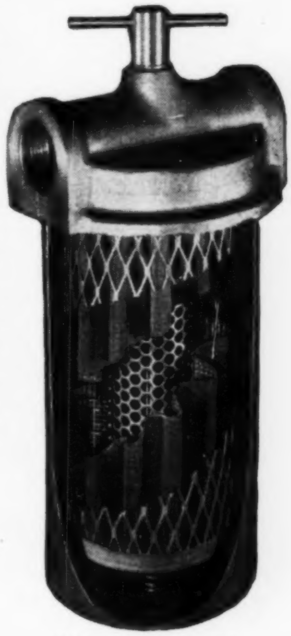
Look For These Important Features

SUMP TYPE (cutaway)



For All Hydraulic and Other Low Pressure Liquid Systems

In the selection of a filter to obtain maximum efficiency and quality, the most important to consider is a specific type filter that will offer greatest ACTIVE filtering area with ample storage capacity for filtered out particles, rather than total filtering area alone. Over 500 Original Equipment Manufacturers install Marvel Synclinal Filters as Standard Equipment because they are designed to give this all-important balance for greatest efficiency in filtration of liquids in all hydraulic and other low pressure circulating systems. Flow of liquids is maintained at a constant, steady rate of speed produced by the pump which brings about the desired effect of a gentle, evenly distributed accumulation of filtered out particles against the entire filtering surface with less restriction of flow. Result—longer periods of productive operation at minimum maintenance down-time. If this important balance is lacking due to efforts to cram too much filtering mesh for the sake of total rather than active area, filters soon become clogged causing pressure build-up, turbulent flow and in general decreases the efficiency of operating equipment. Depend on Marvel Synclinal Filters For All Your Filtration Requirements.



LINE TYPE (cutaway)

EASY MAINTENANCE

Both sump and line types may be easily disassembled, cleaned and reassembled by any workman, on the spot, in a matter of minutes. Line type operates in any position and may be serviced without disturbing pipe connections.

A SIZE FOR EVERY NEED

Available for sump or line installation in capacities from 5 to 100 G.P.M. Greater capacities may be attained by multiple installation as described in catalog. Choice of monel mesh sizes range from coarse 30 to fine 200.

WATER FILTERS

Both sump and line type filters have been adapted for use in all water filtering applications. No changes have been made in the basic, balanced synclinal design.

FILTERS FOR NON-FLAMMABLE HYDRAULIC FLUIDS

Marvel's most recent development is a filter for the efficient filtration of all types of non-flammable hydraulic fluids.

IMMEDIATE DELIVERY!

As in the past, Marvel continues to offer IMMEDIATE DELIVERY.

MARVEL ENGINEERING COMPANY

625 W. Jackson Blvd., Chicago 6, Ill.
Phones: FRANKLIN 2-3530 & FRANKLIN 2-4431

Catalogs containing complete data available on request

MD-12

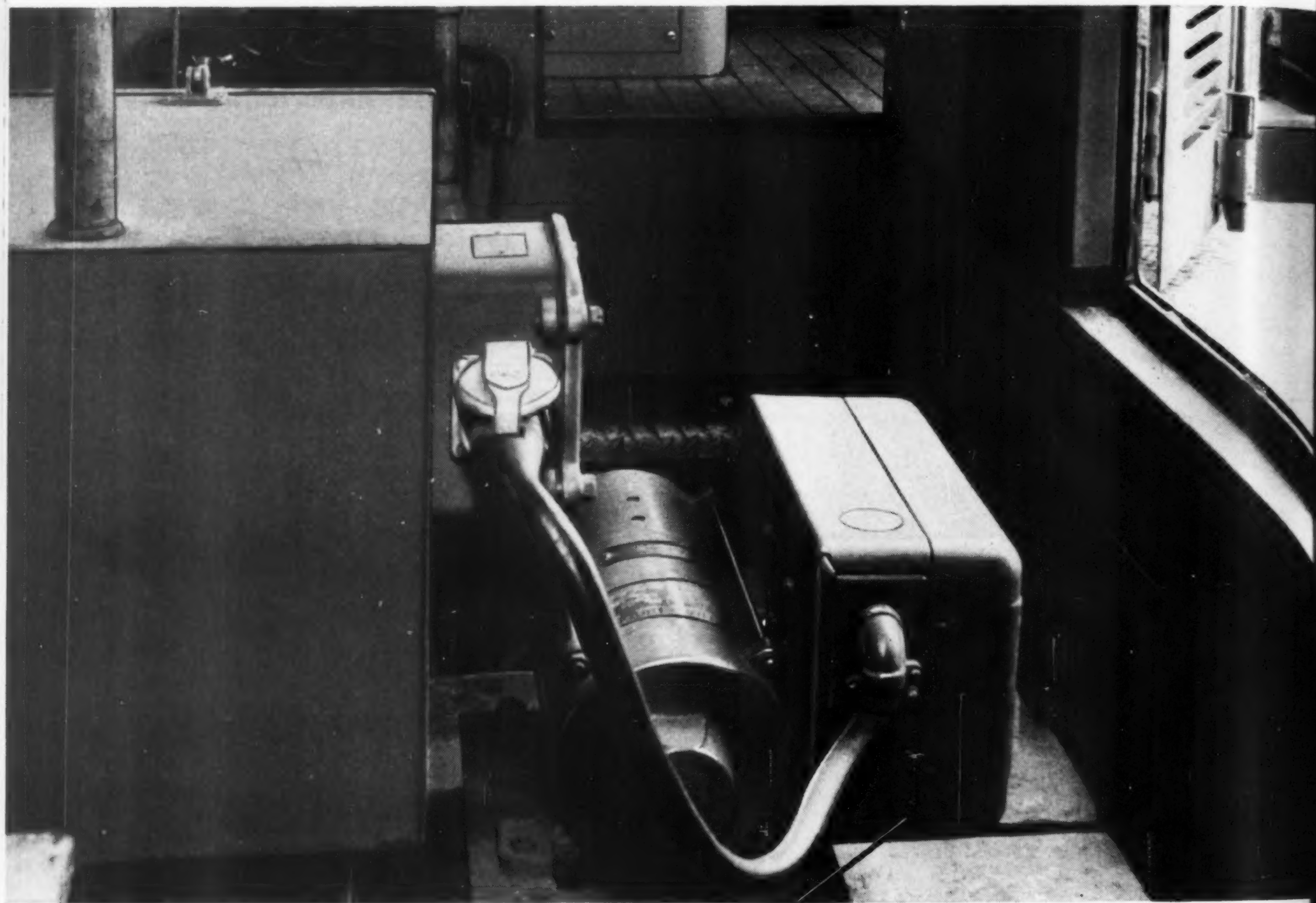
Without obligation, please send me complete data on Marvel Synclinal Filters, as follows:—

- ☐ Catalog #106—For Hydraulic Oils, Coolants and Lubricants
- ☐ Catalog #300—For WATER
- ☐ Data on filters for Non-flammable hydraulic fluids.

Name_____
Title_____
Company_____
Address_____
City_____
State_____

The Erie Railroad story shows why it pays to . . .

Get motor application



THE ERIE RAILROAD REQUIRED motor alternators to provide 115-volt, 60-cycle power for communication equipment between diesel-electric engines, cabooses, and control stations. The railroad had been using a 64-volt battery system. Illustrations (above) show the G-E designed motor alternator—chosen after competitive tests—and location in the engine. At right, is a brief story of how G-E engineers met the rigid specifications and solved the Erie Railroad's particular problem.

help from G-E Engineers

PROBLEM WAS PRESENTED to G-E sales engineer. Erie Railroad required maintenance-free operation for 3 month periods and a design that would make all servicing feasible except rewinding.

PROBLEMS of motor design and motor application are being solved daily at General Electric's Specialty Component Motor Department in Fort Wayne, Indiana. The accumulated engineering experience—unmatched anywhere—starts working for you when you bring your tough motor application problems to General Electric.

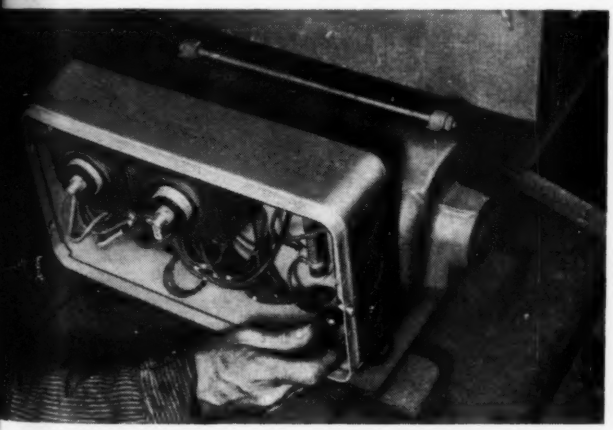
THE ERIE RAILROAD had the problem of providing a dependable power supply for their communications equipment mounted on diesel-electric passenger locomotives, switchers and cabooses. They established their needs as a motor-alternator set supplying 115-volt, 60-cycle current. Close voltage control was necessary to insure satisfactory radio tube operation.

WITH THESE REQUIREMENTS in mind, General Electric designed a 2-unit 2-bearing motor alternator which proved the merit and effectiveness of G-E application help in rugged competitive tests.

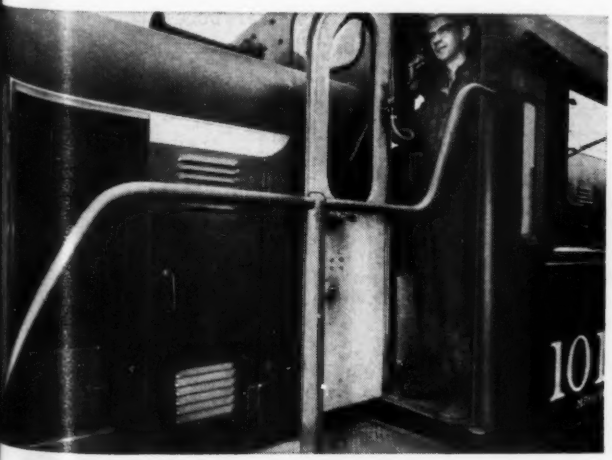
WHEN YOU HAVE a tough motor application problem, take it to General Electric. Take advantage of G-E engineering skill and talent backed by years of experience. Contact your nearby General Electric Apparatus Sales Office. General Electric Co., Schenectady 5, N. Y. 704-21

Progress Is Our Most Important Product

GENERAL ELECTRIC



G-E ENGINEERS at the Specialty Component Motor Department in Fort Wayne, Indiana, designed a special open construction type of motor alternator to meet the railroad's precise specifications.



RUGGED TESTS were given this G-E motor alternator on a switcher in railroad's Marion, Ohio, yard. The design struck a happy medium as to design and service, now used on 75 passenger and yard diesels.

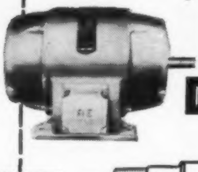
APPLICATION HELP provided by G-E engineers in solving the Erie Railroad's problem typifies the many cases where design engineers have found it pays to take motor application problems to G.E.

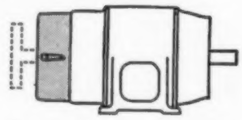
exclusive

REULAND

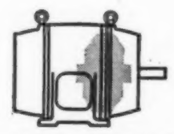
"*Xpandable*" *design*

typical adaptations from this **BASIC DESIGN**

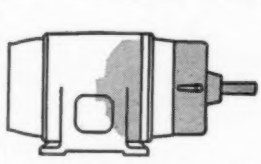




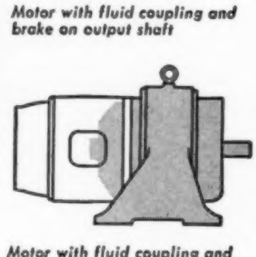
Motor with Reuland "Through Shaft" magnetic brake



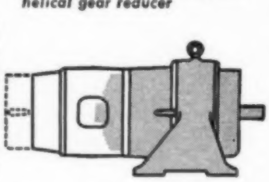
Motor with internal fluid coupling



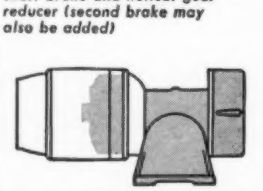
Motor with fluid coupling and brake on output shaft



Motor with fluid coupling and helical gear reducer



Motor with fluid coupling, output shaft brake and helical gear reducer (second brake may also be added)



Motor with fluid coupling, right-angle worm reducer and brake

combines motors • brakes fluid couplings • gear-reducers into tailor-made single-unit POWER PACKAGES!

GREATER COMPACTNESS...

one service responsibility!

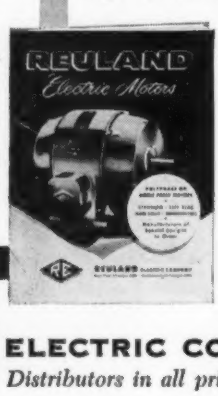
Instead of buying and aligning several separate units, install Reuland *tailor-made, single-unit Power Packages*. You save space and weight, reduce prices up to 25% — simplify installation—improve in-the-field performance.

Literally dozens of combinations are available to fit every powering job. All economical, *standard assemblies* using the basic Reuland "XPANDABLE" motor design.

If your equipment utilizes a motor, brake, fluid coupling, gear reducer (or any combination) why not find out first-hand what a Reuland Power Package can do for you. Give us the details and we'll even submit a "tailor-made" test unit on approval.

OVER 800 "SPECIAL" ELECTRIC MOTOR DESIGNS...

Still further versatility is provided by the Reuland "Library of Specials." Over 800 motors with special electrical and mechanical characteristics... 800 ways you can save development work, get in production faster!



Write today, outlining your particular power problem. No obligation, of course.

RE REULAND ELECTRIC COMPANY

Distributors in all principal cities

WESTERN DIVISION: Alhambra, California • EASTERN DIVISION: Howell, Michigan

New Parts

(*Continued from Page 299*)

Bearing is locked to shaft by engaging self-locking collar with eccentric and tightening setscrew. Shaft rotation increases locking action. Made by **T. B. Wood's Sons Co.**, Chambersburg, Pa.

For more data circle MD-118, Page 241

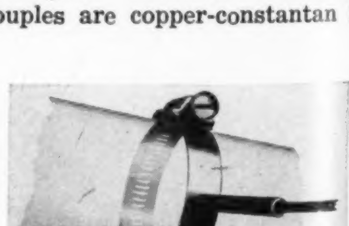
Heat-Resistant Paint

Improved Heat-Rem H-170 combines nonleafing and leafing aluminum particles. The nonleafing particles are said to remain suspended, providing a uniform quantity of aluminum throughout the applied paint coat and making possible virtual fusion of the paint with hot surface metal. A protective coating is formed which is resistant to temperatures of approximately 1700 F. The leafing aluminum content of the paint rises to the surface upon application and is said to form a bright, elastic finish that is resistant to moisture, corrosion, mild acids, alkalis and industrial fumes. Paint will dry at normal temperatures. Made by **Speco Inc.**, 7308 Associate Ave., Cleveland 9, O.

For more data circle MD-119, Page 241

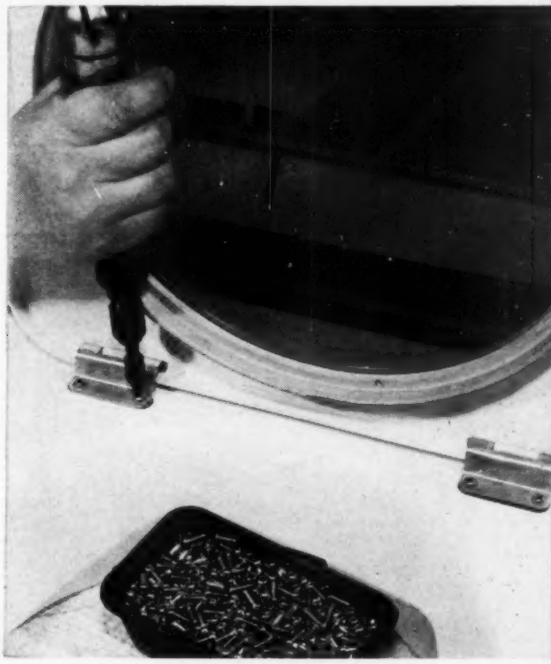
Pipe Clamp Thermocouple

Less than 1 minute is required to install this adjustable pipe clamp thermocouple — opened clamp is placed around pipe, band end is slipped into worm gear housing, and screw is tightened. Thermocouple accurately reads outside pipe temperature. Clamp assembly is stainless steel with a steel spring protecting the thermocouple terminal in clamp. The 20-gage lead wire is 18 in. long and protected by silicone impregnated waterproof insulation. Thermocouples are copper-constantan for



Users praise Phillips Cross-Recessed-Head Screws

DOMINION ELECTRIC COFFEE MAKERS count on the neat appearance and easy installation of Phillips screws. "These screws give us product features we can't get using other screws," states W. A. Reis, Product Engineer. Note, above, that the lower screw that fastens the handle is in a "blind" position and only a little distance from the bottom of the coffee maker. An ordinary one-slot screw would be too difficult to drive on a production line. A part of the coffee maker itself would have to be re-designed.



RUST IS ELIMINATED ON APEX AUTOMATIC WASHER because water can't get under tight bond of Phillips screw heads. Their safety feature is also important. "First," says William A. Haverlock, superintendent of assembly, "it eliminates danger of both worker and customer cutting hands on burrs and sharp edges caused by driver slippage. And, second, it reduces chance of direct injury to assembly personnel from driver." Door hinge, above, is fastened with Phillips screws.

SINGER VACUUM CLEANERS, manufactured at the Finderne, N. J., Plant of The Singer Manufacturing Company's electrical division, use Phillips screws in many applications. "These screws help us maintain a peak schedule," states Francis A. Gall, Vacuum Cleaner Engineer, "they greatly enhance the beauty of our design, eliminate possible damage to exterior finish and provide a means for driving screws into hard-to-get-at places." Gerald Turley here makes difficult angle installations of a Phillips screw in motor.

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY

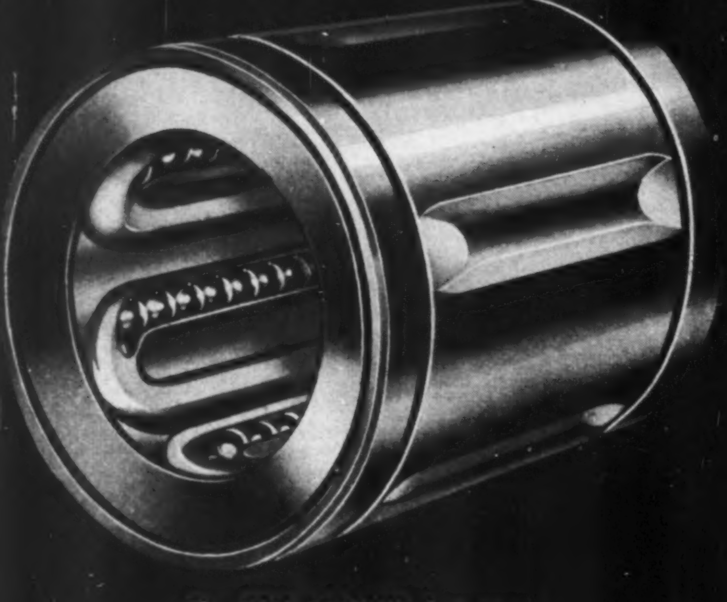
... AND OF THE FUTURE

X marks the spot

... the mark of extra quality

American Screw Company • Atlantic Screw Works, Inc. • The Blake & Johnson Co. • Central Screw Company • Continental Screw Company • The Eagle Lock Company Elco Tool and Screw Corporation • Great Lakes Screw Corporation • The H. M. Harper Co. • The Lamson & Sessions Company • National Lock Company • The National Screw & Manufacturing Co. • Parker-Kalon Div. General American Transportation Corporation • Pheoll Manufacturing Co. • Rockford Screw Products Co. • Scovill Manufacturing Co. • Shakeproof • The Southington Hdwe. Mfg. Company • Sterling Bolt Company • Wales-Beech Corp.

BALL BUSHING



The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A or Low-Cost Series B BALL BUSHINGS.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product. Up-date your design and performance with BALL BUSHINGS!

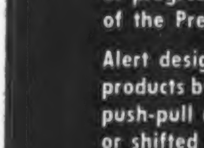
Now manufactured for ¼", ½", ¾", 1", 1½", 2", 2½", and 3" shaft diameters.

LOW FRICTION · LOW MAINTENANCE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LONG LIFE · LASTING ALIGNMENT

Progressive Manufacturers Use Ball Bushings —A Major Improvement at a Minor Cost

THOMSON INDUSTRIES, Inc.

Dept. E, MANHASSET, NEW YORK



Write for descriptive literature and the name of our representative in your city.

Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

low temperatures and iron-constantan for up to 1000 F service. Clamps fit pipe sizes from ⅜ through 4 in. IPS. Made by **Conax Corp.**, 4515 Main St., Buffalo 21, N. Y.

For more data circle MD-120, Page 241

Miniature Clutch

Available as a clutch and as a clutch brake, Micro-Clutch is designed for use in limited space. Maximum diameter is 63/64-in.,

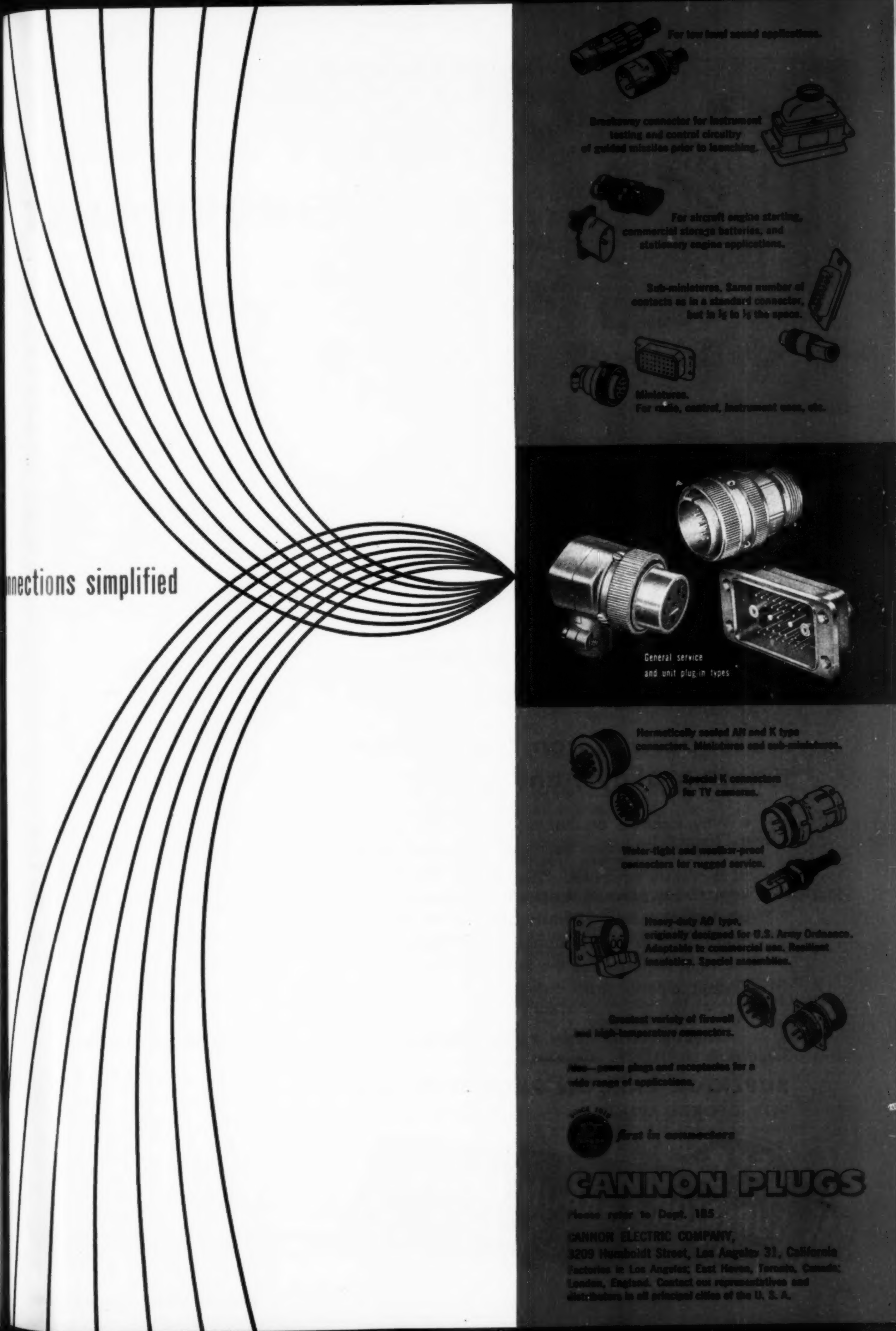
and complete overall length is 2⅛ in., including both shaft extensions. Clutch can transmit a torque of 8 oz-in. with a control current of 65 ma. Made by **Magtrol Inc.**, 533 S. Niagara St., Tonawanda, N. Y.

For more data circle MD-121, Page 241

Hard-Facing Alloy

Applicable by oxyacetylene torch, Walloy No. 6 hard-facing alloy is composed of chrome, cobalt and tungsten. It is usable on edger rolls, swaging mandrels, engine exhaust valves and seats, hot-casting stripper bits and such hot-work tools as punches, dies, shear knives and blades. It provides high impact, corrosion and abrasion resistance; resists oxidation; resists heat-check; and is unaffected by most corrosive chemicals and atmospheres. As-deposited, alloy has Rockwell hardness of 40-44 C, tensile strength of 105,000 psi and melting point of 2325 F. It is available in 3/16, ¼, 5/16 and ⅜-in. rods as well as cast-to-form and as shot for casting applications. Made by **Wall Colmonoy Corp.**, 19345 John R St., Detroit 3, Mich.

For more data circle MD-122, Page 241


nnections simplified
For low level sound applications.
Breakaway connector for instrument testing and control circuitry of guided missiles prior to launching.
For aircraft engine starting, commercial storage batteries, and stationary engine applications.
Sub-miniatures. Same number of contacts as in a standard connector, but in ⅓ to ½ the space.
Miniatures.
For radio, control, instrument uses, etc.
General service
and unit plug-in types
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ENGINEERING DEPARTMENT EQUIPMENT

Tracing Table and Board

Large size Tracemasters have 36 x 48-in. tracing surface. Available mounted on four legs or portable, units are of steel with gray enamel finish. Working area is

illuminated by four fluorescent lamps, and underside is sandblasted to diffuse the light. Table has two adjustments to raise or lower tracing surface to comfortable working angle; portable board is of tilted design. Made by **Stacor Equipment Co.**, 768-778 E. New York Ave., Brooklyn 3, N. Y.

For more data circle MD-123, Page 211

Machine Screws Template

No. 56 small machine screws template has range of six common sizes from 5/16 to No. 6 screws. Root diameter of screws in both elevations can be drawn by using the respective cutouts of the smaller sizes. Both top and side views are provided, as are cutouts for the common screwdriver slots and Phillips' head screwdriver slots. Template is made of

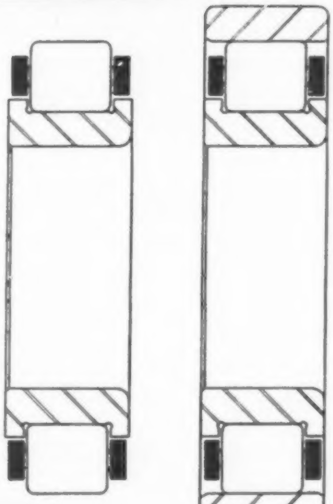
ANOTHER VERSATILE HY-LOAD BEARING...

BU-Z

B indicates composite cage type—rollers spaced by conforming bars riveted to end rings

U indicates that the inner race has flanges at both ends to retain and align the rollers

Z indicates a separable straight cylindrical outer race



The Hyatt BU-Z Bearing is one of two basic Hy-Load types featuring a separable, interchangeable outer race, and is available in four series: 1200, 1300, 5200 and 5300.

Type BU-Z is designed for radial loads where the roller and inner race assembly must be kept with the shaft. The outer race may be omitted entirely, with rollers operating directly on the suitably hardened housing bore. This permits the use of larger-diameter shafts for greater rigidity—or smaller, more economical bearings.

Today thousands of products run smoother and last longer with less upkeep because of Hyatt Hy-Loads. If you're not already profiting from their use, contact your nearest Hyatt sales-engineer or write today for our Catalog No. 150. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

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HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, N. J

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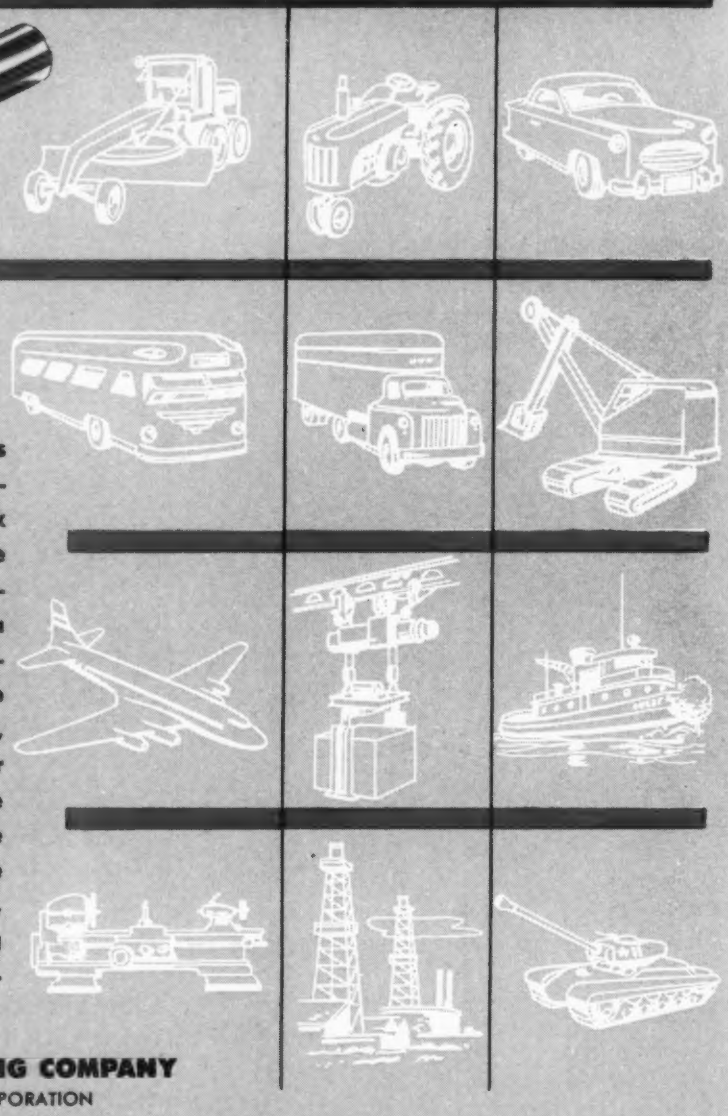

Deep within the equipment that keeps America running are functional assemblies subject to intense vibration, shock loads and constant wear. To provide protection and smooth, trouble-free performance for these assemblies Aetna engineers have teamed with both equipment builders and their suppliers to achieve simplified end product design, higher anti-friction efficiency and lower production and maintenance costs. The results of this cooperative teamwork are written into the success records of the World's finest equipment. Perhaps you, too, can use Aetna's forward-thinking engineering teamwork to good advantage. It costs nothing to find out. Write—

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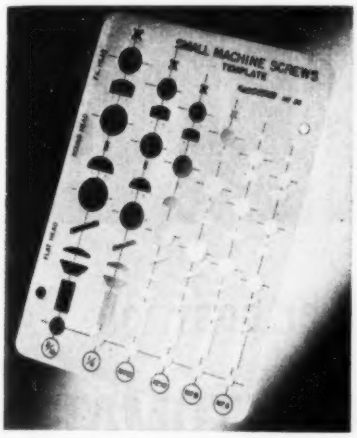


0.030-in. matte finish mathematical quality plastic. All cutouts are precision smooth and have pencil allowance to insure accuracy. Template measures 5 x 6⅞ in. Made by **Rapidesign Inc.**, P. O. Box 592, Glendale, Calif.

For more data circle MD-124, Page 241

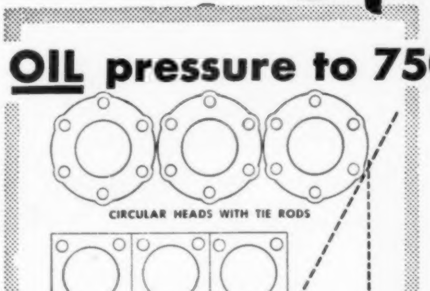
Load Cells

Five new SR-4 load cells of low capacity extend the capacity range of standard cells down to 0 to 50 lb. Three type U-1 cells, designed for loading either in tension or compression, have capacities of 0 to 50, 0 to 100 and 0 to 200 lb.

Designed for tension loads only, two type T-1 cells have ranges of 0 to 100 and 0 to 200 lb. Cells provide means for weighing or measuring static or dynamic loads electronically when used with instruments incorporating simple vacuum tube circuits. Standard cells are operated on either ac or dc at 4 to 8 v. Input resistance is 120 ohms. Calibrated accuracy

(*Continued on Page* 312)

OIL pressure to 750—AIR to 200 P.S.I.



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Here's How the *Original*

Gilmer "TIMING"®

provides a superior spindle drive, at lower cost, on

NEW BRITAIN'S SINGLE SPINDLE AUTOMATIC

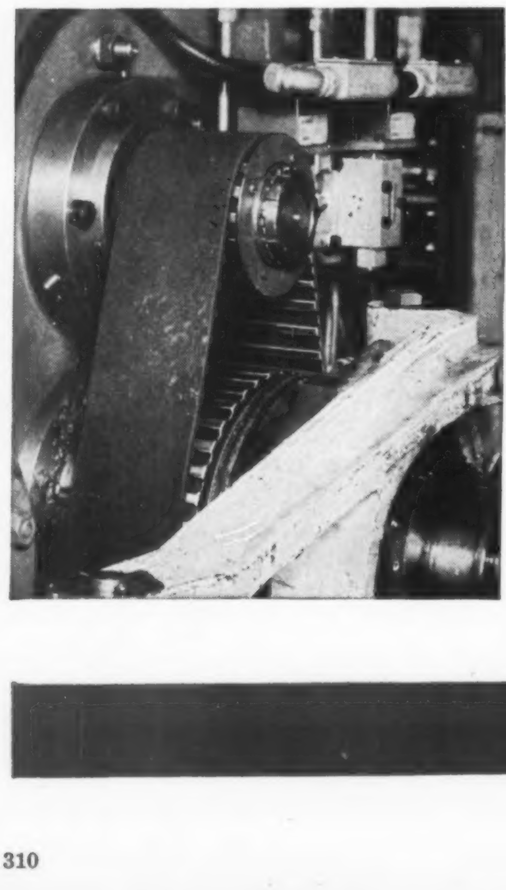
DESIGNERS of some of America's finest machine tools are among the most enthusiastic users of the Gilmer "Timing" Belt Drive. With many, its unique combination of features has made it a "must" on all new model designs!

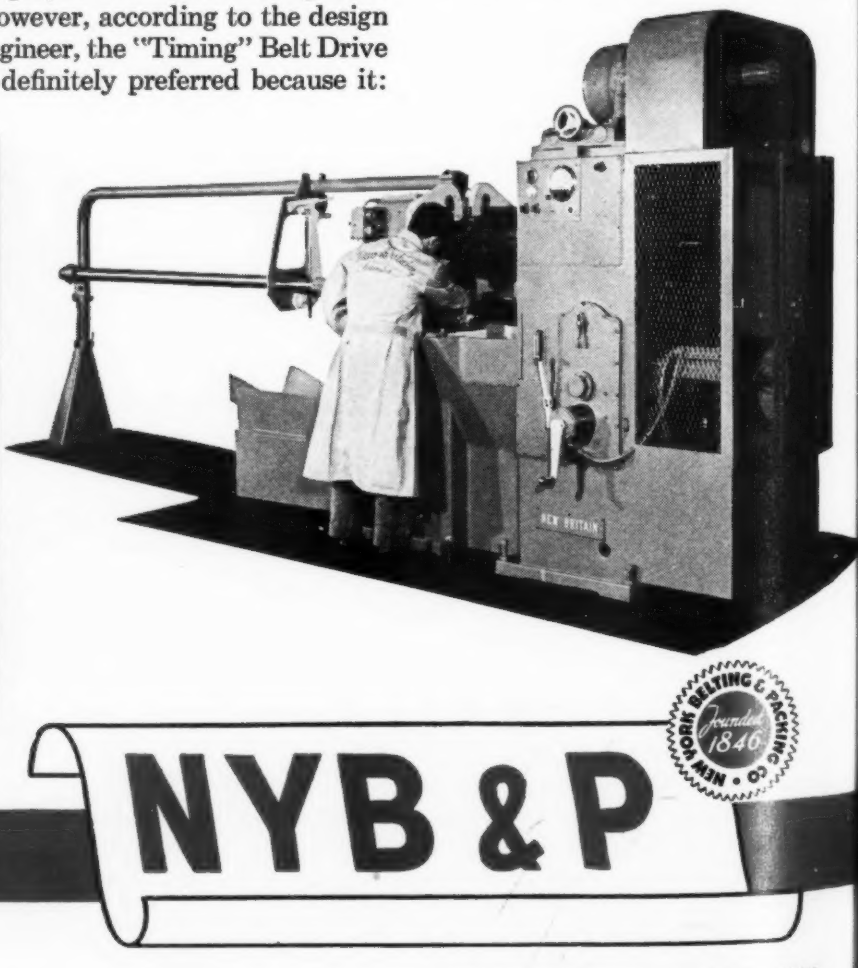
One example is New Britain's Model 126 Single Spindle Automatic Bar Machine. Newest of a proud line of automatic machine tools, its spindle is driven by a 4"-wide "Timing" Belt. Power is provided through a variable speed control by a 15 hp motor at 1750 rpm.

Compactness of the "Timing" Belt Drive is emphasized by the fact that the driving and driven pulleys, mounted on 9⅛" centers, are approximately 4½" and 9" in diameter.

Before the advent of the "Timing" Belt Drive, a train of 3 precision gears would have been employed to drive the spindle. However, according to the design engineer, the "Timing" Belt Drive is definitely preferred because it:

- **Drives the spindle at a constant angular velocity, without slippage or backlash—very important in precision threading operations.**
- **Delivers maximum power to spindle.**
- **Eliminates need for lubricating and housing the drive.**
- **Is quieter, smoother and vibrationless in operation.**
- **All things considered, is least expensive.**





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BELT DRIVE

Industry's Newest Power-Transmitting Medium

Sweeps away design restrictions

In one application after another, "Timing" Belt Drives have enabled machine designers to achieve basic engineering improvements—or to design entirely new machines—that were previously either impractical or impossible! For never before has there been a *positive drive* that combined all these desirable characteristics:

- **Requires no lubrication, no housings or lubricant guards.**
- **Maintains precise synchronization ("timing") between shafts.**
- **Provides speed ratios as high as 15 to 1 in a single step.**
- **Operates satisfactorily at speeds from inches per hour to 15,000 fpm.**
- **Permits use of very small diameter pulleys for ultra-compact drives.**
- **Has nearly 100% mechanical efficiency.**
- **Needs no initial tension. Lighter bearing loads permit lighter bearings.**
- **Does not stretch or lengthen with use; requires no take-up.**
- **Can be designed for zero backlash.**
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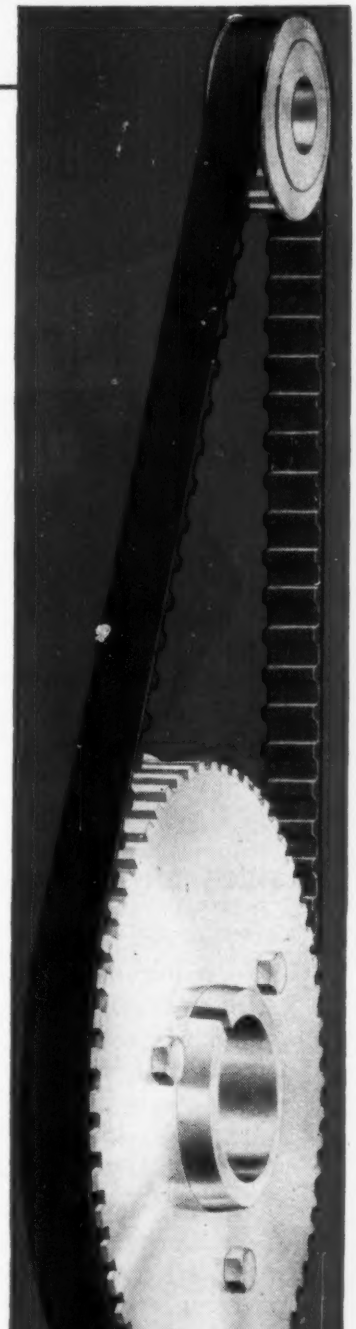
These are but a few of the unique features of this amazing tooth-grip belt drive that is already in successful use on hundreds of thousands of machines. Full details and description are given in the 76-page Gilmer "Timing" Belt Manual, which lists hundreds of drives available promptly from stock. For your copy, call your nearby Gilmer "Timing" Belt Distributor. Or, if he isn't listed in the classified telephone directory, write to the address below.



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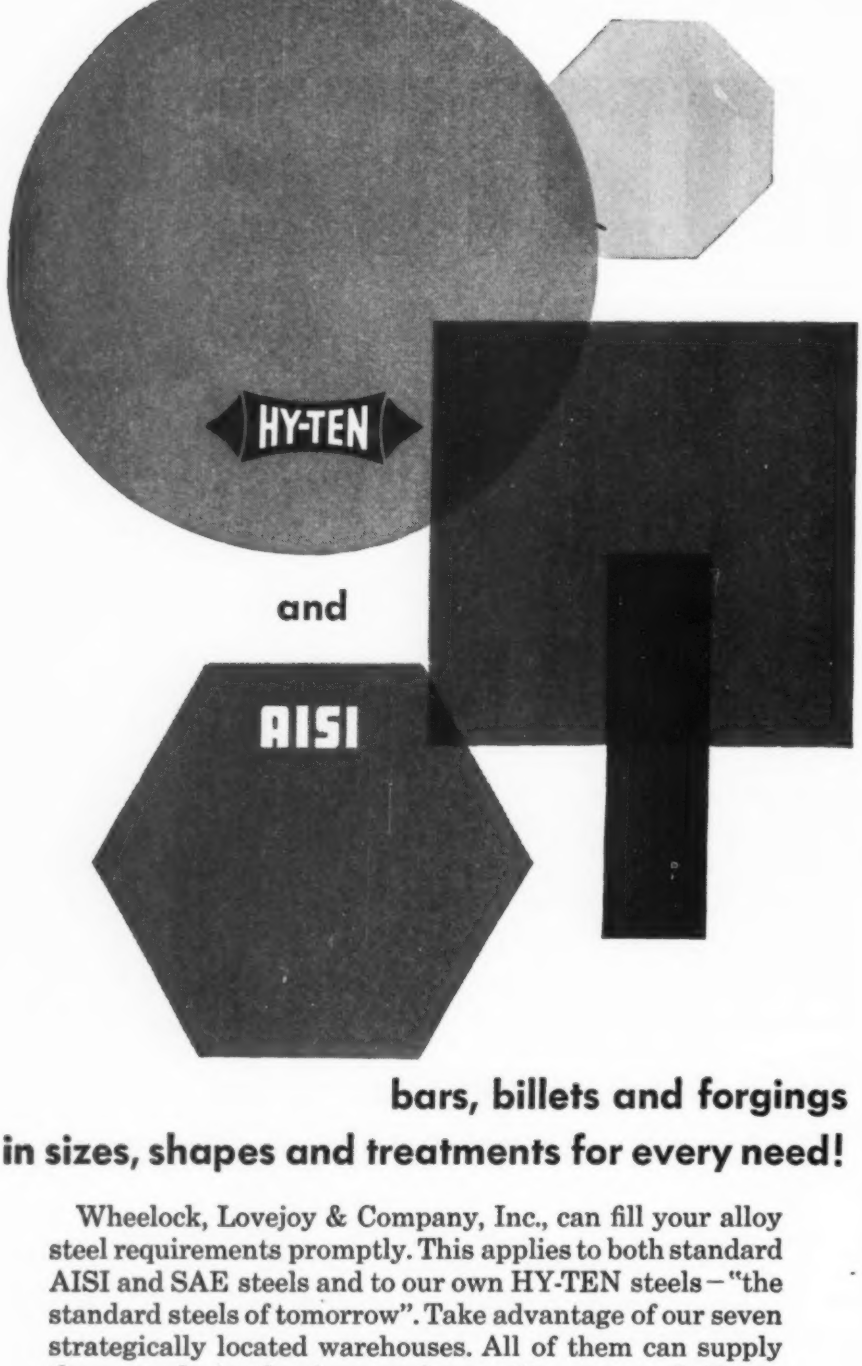

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133 Sidney Street, Cambridge 39, Mass.

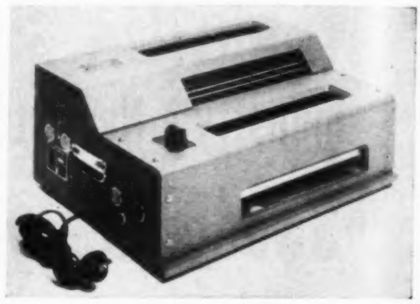
Engineering Equipment

(*Continued from Page* 309)

is within 0.25-per cent of full range. Hermetically sealed containers protect the load-sensitive elements of U-1 cells. The T-1 cells have O-ring seals. Made by **Baldwin - Lima - Hamilton Corp.**, Philadelphia 42, Pa.

For more data circle MD-125, Page 241

Photocopy Machine



Compact, portable dry photocopy machine produces 90 copies per hour of anything typed, written, printed or drawn. It makes one or two-sided copies up to 9 in. wide and any length. Machine can be operated under normal light conditions. Interior is stainless steel; exterior is finished in gray vinyl. Machine operates on 110 v ac. Made by **General Photo Products Co. Inc.**, General Photo Bldg., Chatham, N. J.

For more data circle MD-126, Page 241

Lead Holders

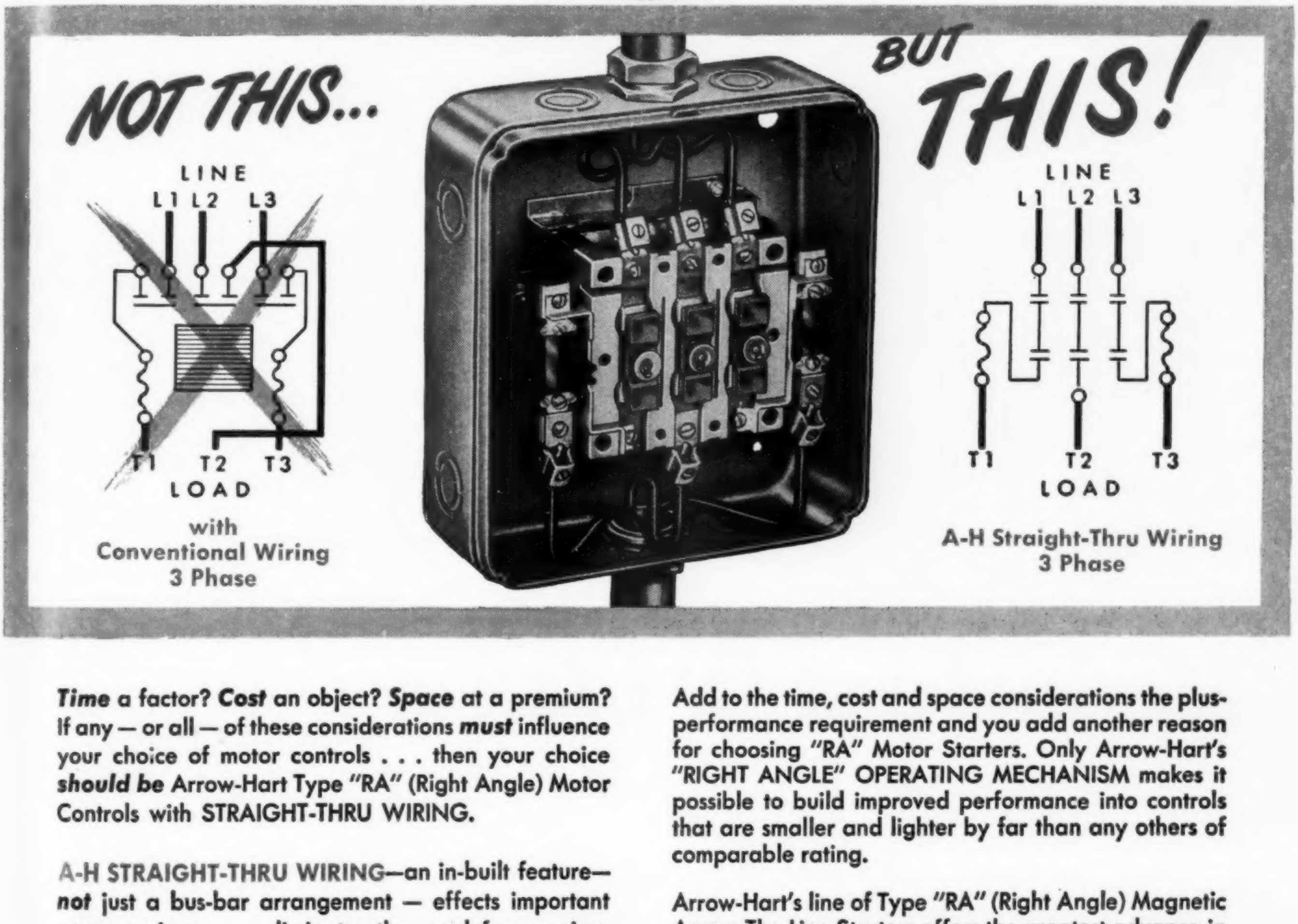
Complete operating mechanism of TruPoint automatic lead holder is located in the finger-grip portion of the holder. Distribution of weight obtained by this design provides balanced writing comfort. Holder is all metal, with a patterned gripping surface. Press-top, automatic single end and automatic double end models are available. Companion TruPoint pencil pointer is built for one-hand operation for extending the lead to a predetermined length and a writing point up to ½-in. without breaking. Lead holder can be stored in receptacle of pencil pointer. Made by **Elward Mfg. Co.**, Baker St., Coloma, Mich.

For more data circle MD-127, Page 241

Time-...Cost-...Space-Saving STRAIGHT-THRU WIRING

...one of many *Advanced Design* features of

ARROW·HART TYPE "RA" MAGNETIC MOTOR CONTROLS



Time a factor? ***Cost*** an object? ***Space*** at a premium? If any — or all — of these considerations ***must*** influence your choice of motor controls . . . then your choice ***should be*** Arrow-Hart Type "RA" (Right Angle) Motor Controls with STRAIGHT-THRU WIRING.

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Add to the time, cost and space considerations the plus-performance requirement and you add another reason for choosing "RA" Motor Starters. Only Arrow-Hart's "RIGHT ANGLE" OPERATING MECHANISM makes it possible to build improved performance into controls that are smaller and lighter by far than any others of comparable rating.

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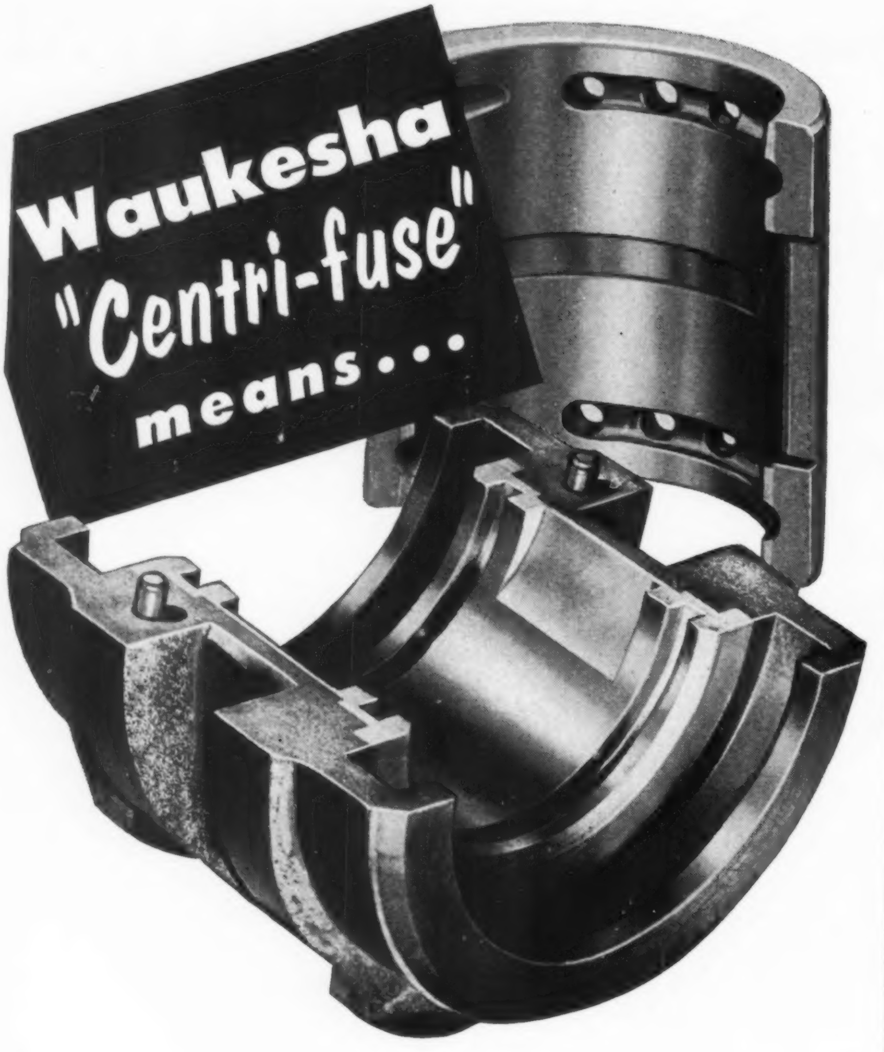

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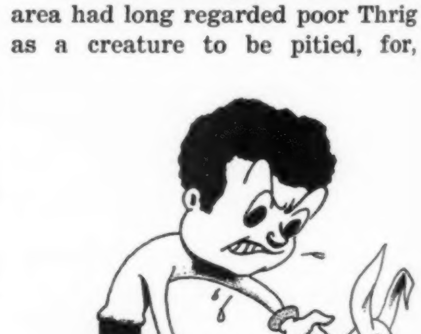
Stress Relief

MECHANISMS are the things machines are made of. And mechanisms continue to be the object of intense development, as evidenced in this issue by Transactions of the Second Conference on Mechanisms. Sometimes, though, we wonder about the origin of some of the basic types of mechanisms. Here Gene Murphy of Minneapolis-Honeywell, reconstructs the invention of one kind.

Thrig and His Lynx

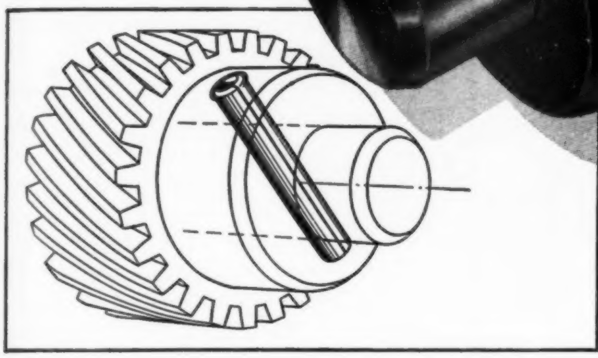
In the far northern reaches of Europe, there dwelt, many years ago, a rather simple minded fellow called Thrig who kept his body and soul together by snaring various and sundry wild creatures, whose pelts he exchanged for food and such other necessities of life as were at that time available.[1]

The more intelligent folk of the area had long regarded poor Thrig as a creature to be pitied, for,



while they were gainfully employed in farming or wine-making, or such other activities as their brains might best enable them to perform, the witless Thrig must needs range the forests primeval in search of such creatures as might be of lesser stature than he, both mentally and physically,

[1]The smart people who had the food and other things worked 16 hours a day. Thrig worked 4 hours a day.



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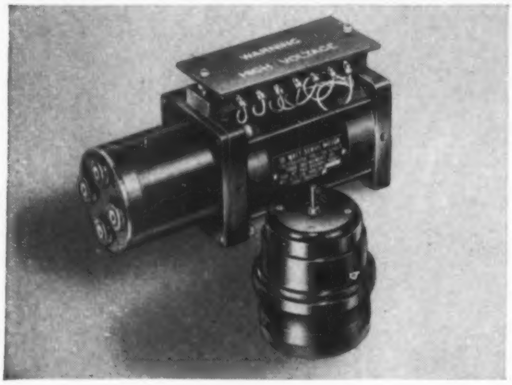

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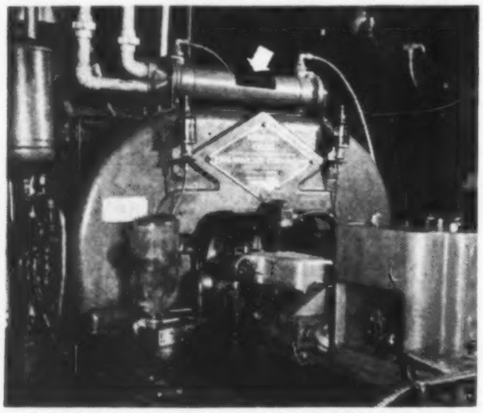

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NATIONAL CAN CORPORATION uses Young oil-to-water Heat Exchangers to cool bearing lubricating oil on can body making machines. These machines take flat, lithographed bodies and form and lock the side seams. Before installing the Young Coolers, heat generated by friction of the machine caused the lubricating oil to form a varnish, freezing-up the bearings. This resulted in considerable machine down time for cleaning. With the installation of efficient Young Heat Exchangers on all machines in the plant, bearing freeze-ups no longer occur. Young Heat Exchangers are available with fixed or removable tube bundles for fresh or salt water applications. For further details see your Young Representative or write direct.

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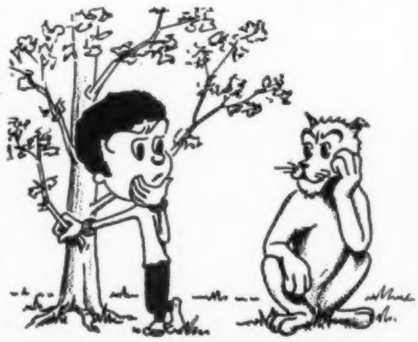
so that he could entrap them in his snares.[2]

This situation, however, bothered Thrig not in the least, and he was more than content to range the forests, for, indeed, a good deal of his ranging was done on the flat of his back in the shade of some great tree. For he reasoned, and not too incorrectly, that there was only one of him while there were many multitudes of furry creatures, and why should just one of him go in search of all of them when it would perforce be so much simpler for all of them to come in search of him.

But one fine day, while he was doing some of his best ranging, there slunk from the bushes before his horrified eyes the great grandfather of all lynxes. This lynx, a creature of magnificent proportions, sat himself down and regarded Thrig with great seriousness. Thrig, in turn, regarded the lynx, and with considerably more seriousness, for the beast not only



obviously exceeded him in physical stature but also showed manifest signs of being of considerably more intelligence.[3]

"Being simple minded," said Thrig to himself, "and therefore not able to outwit this beast, it is best that I make friends with it." And, so saying, he drew from his pocket a bologna which he broke into two halves. One half, he stuffed into his mouth; the other he proffered to the lynx who accepted it gravely and thanked him by means of two or three musical belches.[4]

From that time on, the two were inseparable, and Thwap, as

[2]Since, Thrig was a little guy and not too strong in the brain department, he did a lot of forest ranging.
[3]Even so, he wouldn't have had to be too clever a lynx.
[4]Lynxes have a weakness for bologna.

Thrig called his friend, was of great help in ranging the forests and trapping furry creatures. In return for this, Thrig turned over to Thwap some two-thirds of the

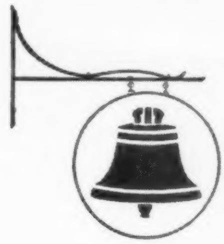
proceeds from his fur swapping activities. Now it so happened that both Thrig and Thwap made their home in a fallen hollow tree. This tree had fallen so that some one-third of its length projected over a small ravine at the bottom of which ran a small stream from which both man and beast obtained their drinking water.

At such times as Thrig visited the nearby village for the purpose of swapping furs for food, it was his custom to fasten Thwap securely to one end of the hollow tree by a rope of strong vines.[5] This he needs must do, else Thwap would follow him to the village thereby frightening away the villagers and rendering the swapping activities somewhat difficult.

One day, Thrig, having returned from the village, was sitting astride the end of the hollow tree that projected out over the stream. In his hands he held a bucket, and he was thinking how nice it would be if he could but lower the bucket down and draw it back up brimming with cool clear water, instead of having to climb down the rocky wall of the ravine, fill the bucket, and claw his way back to the top.[6]

Thwap, who Thrig had forgotten to untie, slept happily at the other end of the hollow tree, some 40 feet away. Without warning, there came a crackling in the bushes, and into the clearing stepped two wise men of the village. Thwap, awakened suddenly, and in great fear, ran quickly up the trunk of a tree at the foot of which he slept. Being still fastened to him by the vines, the end of the hollow tree followed close

[5]Thwap was allergic to rope.
[6]One of his grandsons thought up the automatic factory.



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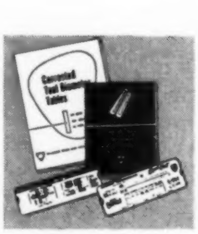

PRODUCTION AND DESIGN ENGINEERS will want two Alcoa booklets, *Alcoa Aluminum in Automatic Screw Machines* and *Corrected Tool Diameter Tables*. Also available at no extra cost are two precision computers —a Speed-Feed calculator, and an alloy property guide which shows at a glance the various properties of Alcoa Aluminum Screw Machine Stock.

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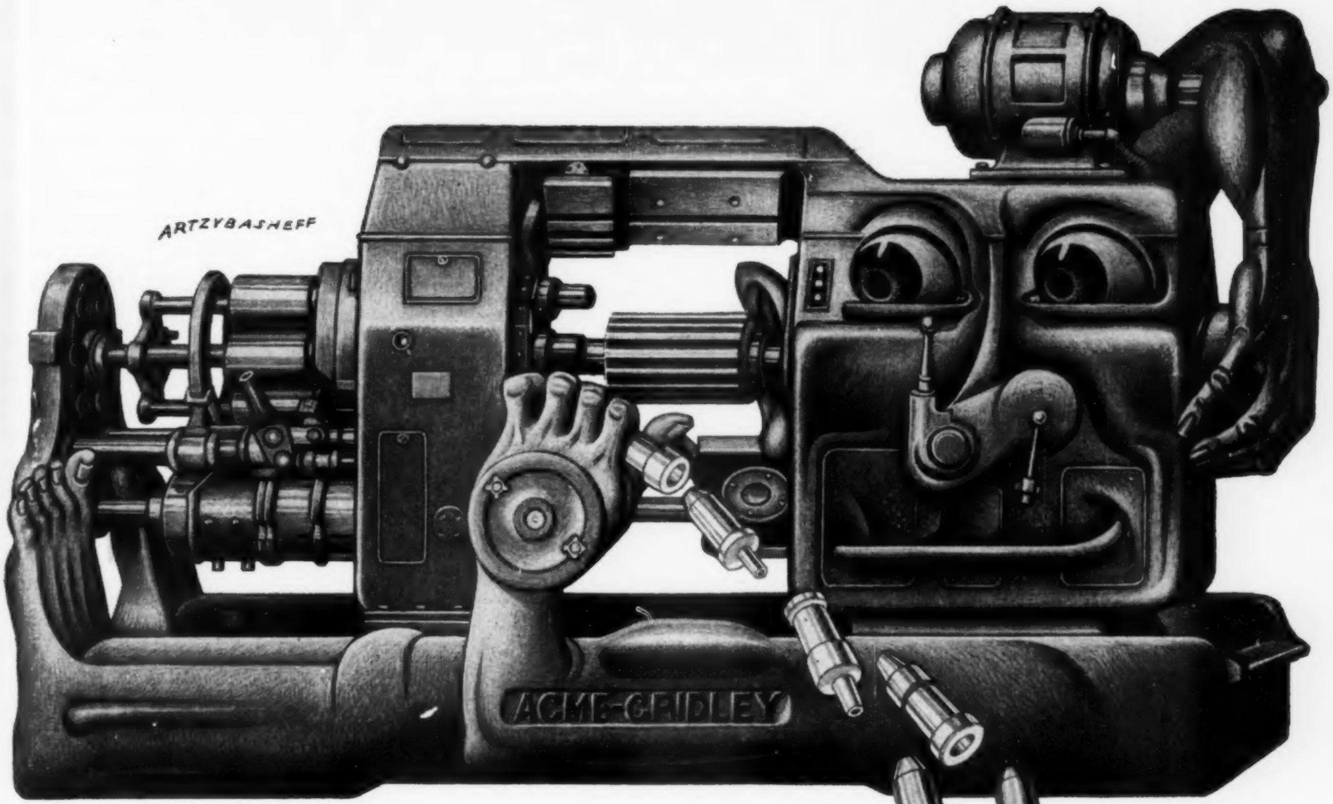

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Alcoa offers *Alcoa Aluminum in Automatic Screw Machines*, a 95-page book containing information on tool design, setup and operating techniques. It is available to you at no cost just by writing on your company letterhead telling us your job function.

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BIG NEWS in SPEED CONTROL

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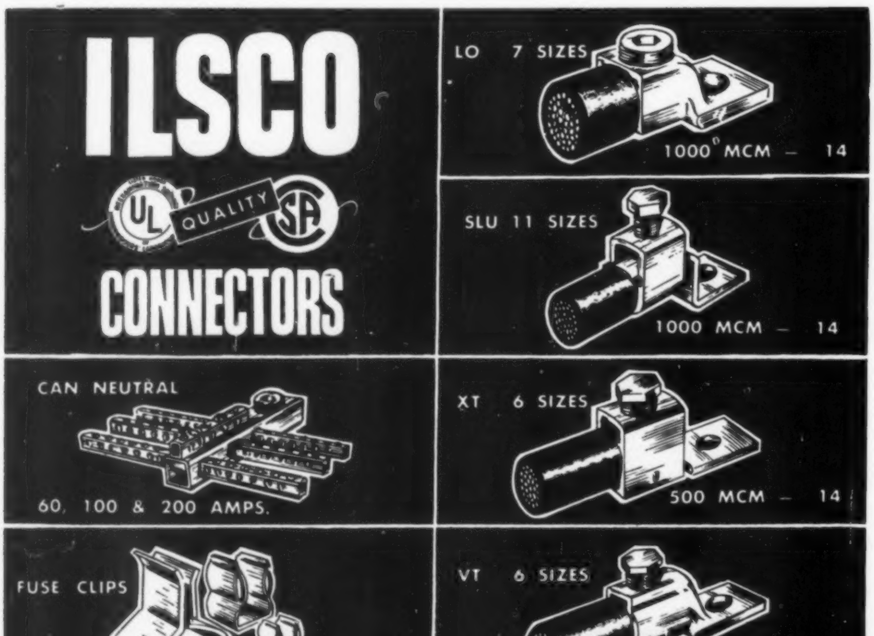


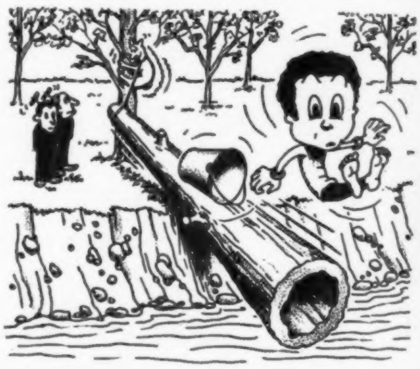
(Continued from Page 319)

behind him. With the bank of the ravine as a fulcrum, the tree pivoted, depositing both Thrig and the bucket into the stream.

"Oh Thwap," called Thrig when he had rid his lungs of water, "come back down or else I shall most certainly drown!"

Soothed by the voice of his friend, Thwap backed down the tree, and the end of the hollow tree descended with him. The other end, bearing Thrig and his bucket of water, rose to its former place above the stream.

Thrig was very much excited and not a little pleased, for now he had hit upon a way to draw water from the stream without



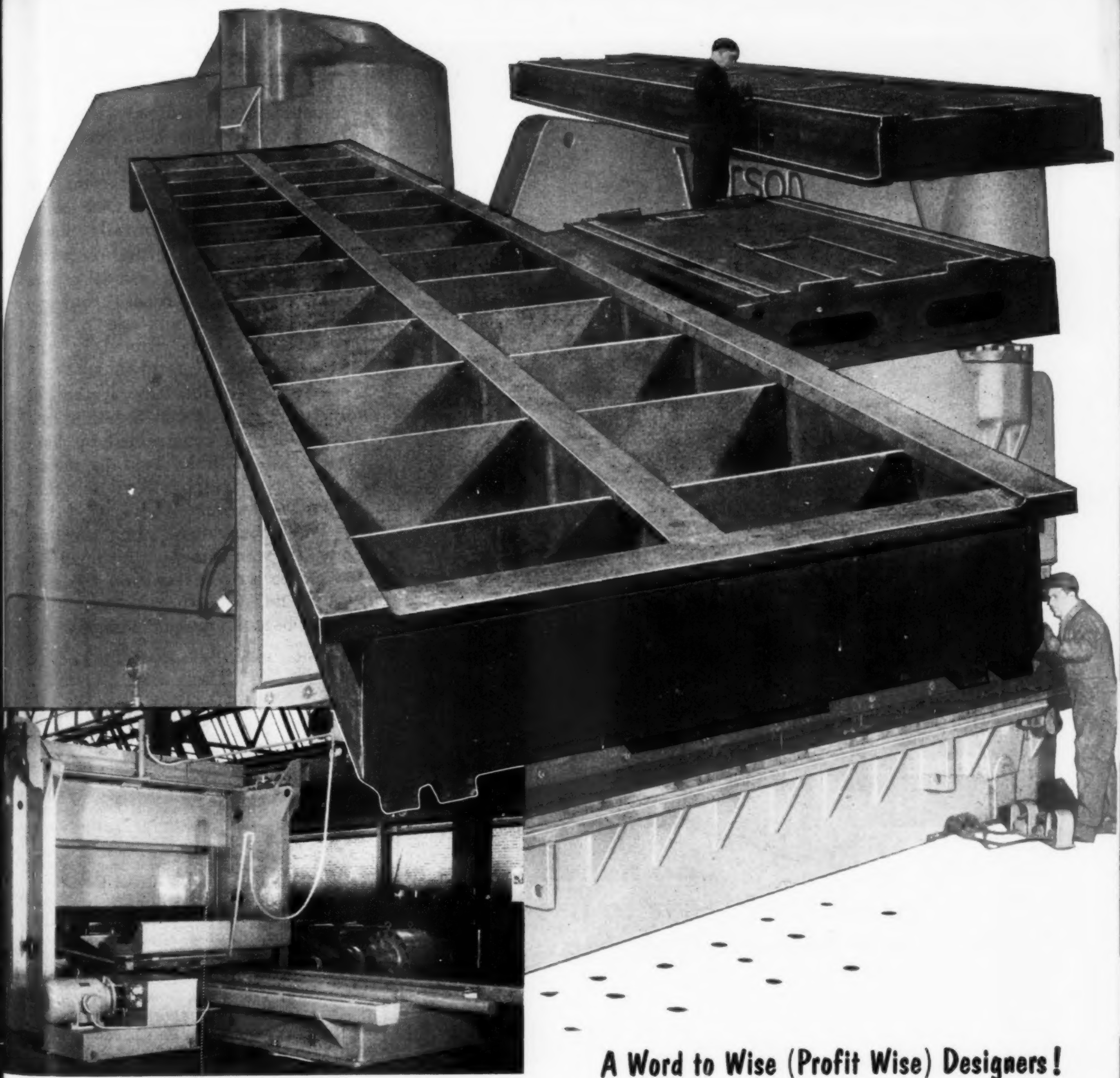
clambering down the side of the ravine. In truth, he well nigh drowned each time he drew a fresh bucket, but that was of little consequence to him so long as he was spared the torture of physical labor.[7]

The two wise men from the village, observing what transpired, were much impressed, and, being wise men, were of the opinion that such a thing should have a name.

"It is clearly," said one wise man who, in his youth, had aspired to become an engineer, "an application of force at one end of this hollow tree which causes the end to rise, allowing the other end to descend into the stream."[8]

"If by that you mean that one end goes up, and the other down, I must needs agree," said the second wise man who, in his youth, had aspired to become a wise man. "As for this 'force' of which you

[7]Later he received an honorary doctor's degree from some engineering school.
[8]He had taken a course in applied mechanics in first grade and it had gone to his head.



A Word to Wise (Profit Wise) Designers!

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Shown above is the new and world's largest precision abrasive belt grinder—designed and built by Hill Acme of Cleveland, Ohio. The three weldments shown form the base for this machine. Bending played a large part in the forming of this base.

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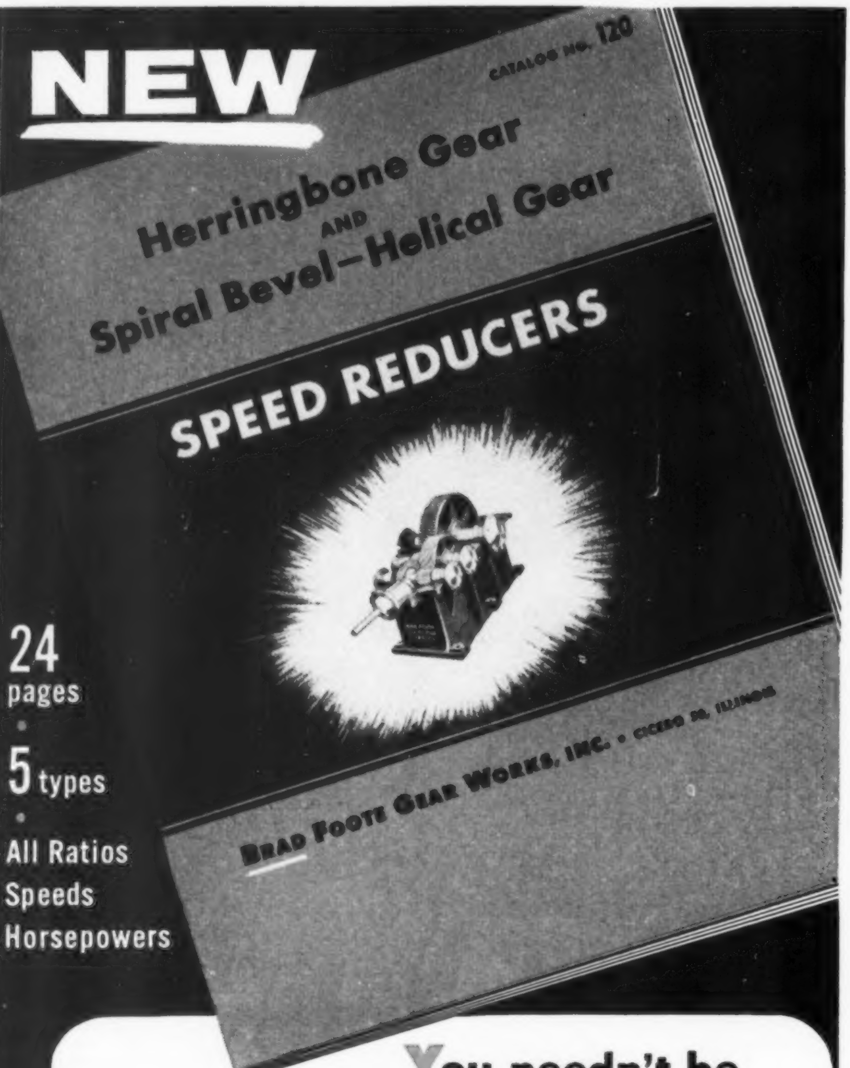

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Stress Relief

mumble, I can see only that the tree is acted upon by a lynx, and one of great age at that."

"To a certain extent, you are right," said the first wise man, "and since the term falls pleasantly upon the ear and is sufficiently vague to confuse all others save us two, I propose that we call this thing a lynx age."[9]

And this term, coined by the two wise men, was for many years used to describe any system of links or bars joined together and more or less constrained by having a link or links fixed, by means of which straight lines or other point paths may be traced.

Only, somewhere along the line, an engineer who couldn't spell decided to write a book on the subject, and, ever since, these devices have been known as *linkages.*

[9]During his life, he wrote a number of engineering text books.

The Chief's Lament

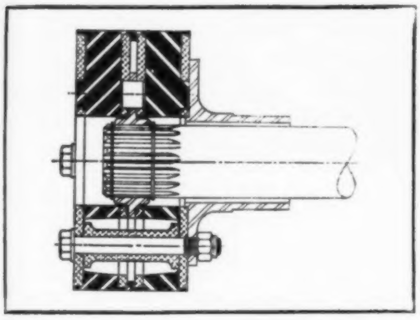
As everybody knows, an Executive has practically nothing to do . . . except decide what has to be done . . . tell somebody to do it . . . listen to reasons why it should not be done . . . why it should be done by somebody else . . . why it should be done a different way . . . to prepare arguments in rebuttal that shall be convincing and conclusive . . . to follow up to see if the thing has been done . . . to discover that it has not been done . . . to inquire why it has not been done . . . to listen to excuses from the person who should have done it . . . and did not do it . . . to follow up a second time to see if the thing has been done . . . to discover that it has been done but done incorrectly . . . to point out how it should have been done . . . to conclude that as long as it has been done . . . it may as well be left as it is . . . to wonder if it is not time to get rid of a person who cannot do a thing correctly . . . to reflect that the person at fault has a wife and seven children . . . and that certainly no other executive in the world would put up with him for another moment . . . but that . . . in all probability . . . any successor would be just as bad . . . and probably worse . . . to consider how much simpler and better the thing would have been done if he had done it himself in the first place . . . to reflect sadly that if he had done it himself he would have done it right in twenty minutes . . . but that as things turned out . . . he himself spent two days trying to find out why it was that it had taken someone else three weeks to do it wrong . . . and then realize that such an idea would strike at the very foundation of the belief of employees that . . . executives have nothing to do.

—Anonymous

(Advertisement)

Lord Flexible Coupling Flies With Kaman Helicopter

The Kaman K-5 helicopter presents an interesting application of the LORD J-5329-2 flexible coupling with the Boeing 502-2 gas turbine. The function of the coupling in this case is to absorb the torsional vibrations of the system and isolate the turbine from the rotors. However, the unit also serves to accommodate angular or parallel misalignments due to manufacturing tolerances or dynamic motions.



The unique design of the installation provides maximum accessibility and economical maintenance through the use of concentric driving and driven shafts. The inner member of this pair is the engine shaft which drives the coupling hub through a splined connection. Precompressed against the splined hub are the two bonded rubber coupling halves which transmit the engine torque in shear of the rubber. Four through-bolts connect the outer plates of the coupling halves to the driven hub and also serve as the safety interlock in case the rubber sections are destroyed. The first gear of the transmission is mounted on this driven hub and feeds power on through the system in to the helicopter rotors.

For over thirty years the Lord organization has specialized in designing and producing Bonded Rubber Flexible Couplings, Vibration and Shock Control Mountings and Component Parts. The capabilities of Lord Engineering have proved their worth to designers of industrial and automotive equipment in many diversified fields as is indicated in this instance.

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LORD *Flexible Couplings*

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HERE again you see at a glance Lord versatility in designing bonded-rubber components for a wide diversity of machines. The photo at top right shows the Boeing Gas Turbine-Driven Truck-Trailer for heavy cargo hauling. At the top left you see a United States Navy personnel boat driven by the Boeing Gas Turbine Engine. Directly beneath is the Kaman Helicopter powered by the Boeing Gas Turbine Engine; details are clear in the foreground. The Lord Bonded-Rubber Flexible Coupling designed for the job transmits the power in each machine.

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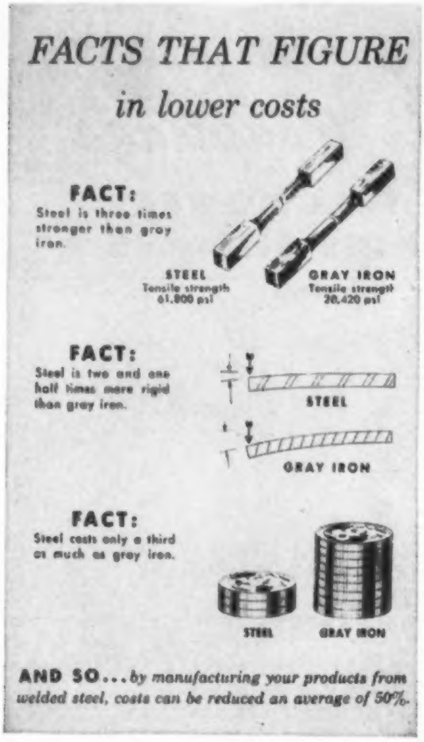

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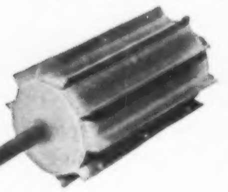
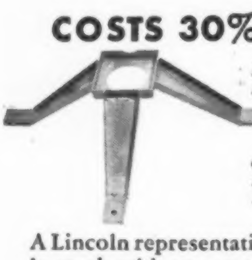


Feeder roll is built from standard channel welded to steel discs. Steel design eliminates breakage, weighs half of former casting. Saves 45% on cost of manufacture.

COSTS 30% LESS



Machine bracket is welded from 10 gauge metal. Weighs half as much as original cast design. Costs 30% less to produce.

A Lincoln representative will gladly work with you to cut your production time. He can show you how to simplify design details . . . cut costly man-hours. Call him or write on your letterhead.

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THE ENGINEER'S Library

Recent Books

Hydraulic Systems and Equipment. *By R. Hadekel, consulting engineer, London, England; 232 pages, 5½ by 8½ inches, clothbound; published by Cambridge University Press, New York; available from* MACHINE DESIGN, *$3.75 postpaid.*

This book, much of which appeared as a series of articles in MACHINE DESIGN in 1953, discusses design, power and control aspects of hydraulic systems and components. Necessary elements of fluid mechanics are outlined in the introductory chapter. Basic principles of control gear are covered in Chapter 2. In Chapters 3 to 10 attention is mostly focused on circuit problems, with necessary information regarding control gear introduced where required. The remaining four chapters treat equipment from the standpoint of detail design, manufacture and installation.

Detailed information is given on those systems used to control airplanes, automatic machine tools, etc., and to transmit power in such machines as automobile brakes, fork lift trucks and hydraulic presses.

Of particular interest are the types of systems such as series-sequence systems and variable-area systems.

♦

Electronics. *By A. T. Starr; 403 pages, 5½ by 8½ inches, clothbound; published by Pitman Publishing Corp., New York; available from* MACHINE DESIGN, *$7.50 postpaid.*

Physical and mathematical aspects of electronics are emphasized in this textbook. The first chapter describes qualitatively the modern theories of metals, semiconductors, emission of electrons and gaseous discharges. The remaining five chapters cover tubes, rectification, circuit theory, amplifiers, oscillators, detectors and electronic applications. Appendixes include mathematical formulas, steady-state ac theory, Fourier analysis, power level, operational calculus, Laplace transform method, Maxwell's equations, and noise.

♦

Copper. *Edited by Allison Butts, head, department of metallurgical engineering, Lehigh University; 950 pages, 6 by 9 inches, clothbound; published by Reinhold Publishing Corp., New York; available from* MACHINE DESIGN, *$20.00 postpaid.*

This volume, one of the American Chemical Society Monograph Series, is intended to provide a reference work on all important phases of the subject of copper both as a chemical element and as an industrial metal. Forty-six chapters, each written by one or more specialists on the subject, cover important fundamental principles, latest practices in the industry, and many less well-known applications of copper.

Among topics receiving full chapter treatment are: copper smelting, converting and refining; melting and casting; physical and chemical properties; corrosion resistance; brass, bronze and other copper alloys; hot and cold working; physical and analytical chemistry of copper; phase diagrams of binary and ternary copper alloys; details of applications in various industries; and copper compounds.

♦

Bibliography on Research Administration. *By George P. Bush, professor, The American University; 152 pages, 6 by 9 inches, clothbound;*

The Engineer's Library

published by The University Press of Washington, D. C.; available from MACHINE DESIGN, *$4.00 postpaid.*

This book is primarily concerned with research and development administration in the United States, although some British and other foreign references are included. It is directed to those concerned with government and industrial research. More than 1100 current references are listed, with short descriptions. The eight parts include bibliographies and abstracts, general references, research process, budget and finance, organization and management, personnel administration, external relations, and research in action. An author index and topical index are appended.

♦

The Design and Use of Instruments and Accurate Mechanism. *By T. N. Whitehead; 299 pages, 5½ by 8 inches, cloth or paperbound; published by Dover Publications Inc., New York; available from* MACHINE DESIGN, *clothbound $3.95 postpaid, paperbound $1.95 postpaid.*

Although the principles discussed in this book are primarily for the guidance of instrument designers, most of them are equally applicable to mechanisms in general. After an introductory chapter on instruments and their parts, Part 1 covers systematic errors, probability, short-period errors, and erratic errors. Part 2 discusses precision, kinematic and semikinematic design; stiffness, isolation and protection of elements; accuracy; planning of an instrument; and the human factor.

Association Publications

Resistance Welding of Copper and Copper Base Alloys. *9 pages, 8½ by 11 inches, paperbound; available from Resistance Welder Manufacturers' Association, 1900 Arch St., Philadelphia 3, Pa., ten cents per copy.*

Discussed in this bulletin are various factors influencing weldability of copper and copper base alloys, as well as technical aspects of the welding processes recommended. Helpful tables and illustrations are included.

Manufacturers' Publications

"Timing" Belt Drive Engineering Handbook. *By Richard Y. Case; 201 pages, 5½ by 8½ inches, clothbound; available from United States Rubber Co., Rockefeller Center, New York 20, N. Y., or New York Belting and Packing Co., 1 Market St., Passaic, N. J., $3.50 per copy.*

Written by the Timing belt inventor, this handbook provides the designer with all pertinent engineering data necessary for the incorporation of Timing belt drives in original equipment. Standard drive tables are included.

♦

Welding Alcoa Aluminum. *176 pages, 5¼ by 8¼ inches, paperbound; copies available from Aluminum Company of America, 733 Alcoa Building, Pittsburgh 19, Pa.*

New developments in the technology of welding aluminum alloys are reflected in this booklet. In addition to basic, practical data on individual processes, it includes information on choice of method. Methods covered include gas, spot, seam, flash, arc and pressure welding, and welding aluminum castings.

New Standards

ASTM Tentative Specifications. *Each publication is 6 by 9 inches, paperbound; copies available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.*

The following Tentative Specifications are available:

A 6-54 T. **General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use**—18 pages.

A 213-54 T. **Seamless Alloy Steel Boiler, Superheater, and Heat Exchanger Tubes**—10 pages.

A 214-54 T. **Electric-Resistance-Welded Steel Heat-Exchanger and Condenser Tubes**—5 pages.

A 249-54 T. **Welded Austenitic Stainless Steel Boiler, Superheater, Heat Exchanger and Condenser Tubes**—8 pages.

B 285-54 T. **Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes**—10 pages.

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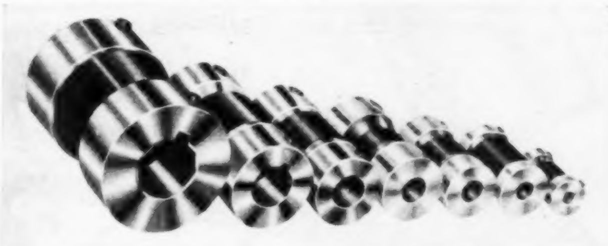

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FROM OUR PRODUCT APPLICATION FILE

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Problem: A deposit drawer for drive-in banking activates a limit switch just before reaching the extreme limit of its travel. The momentum built up by the gearhead motor imposes approximately 50 in. lbs. upon the arrested motion of the drive train. To protect the gears against this sudden shock a flexible coupling is required which will deflect flexibly 20° in rotation under this load.

Solution: A study of the load deflection involved, with the normal running torque in this drive, found its answer in one of the several Flex-Elements available in Dyna-Line couplings. The No. 3-R in 4¼ inch length was then selected. No premium price for so-called "non-standard length".

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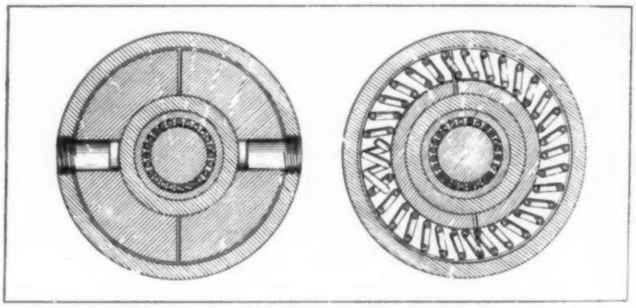
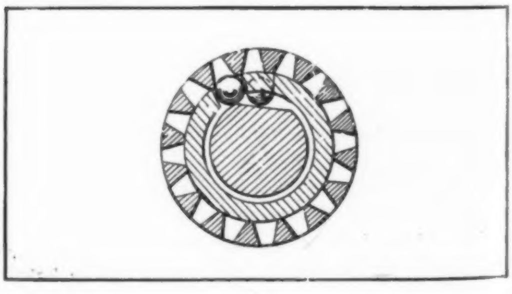
Patents

Automatic disengagement of rotating shafts at predetermined speeds is offered by a centrifugally actuated clutch. Positive driving engagement is obtained through semi-circular shoes which grip the driven shaft and are held in frictional contact by garter springs. As rotational speed reaches a predetermined value, centrifugal force acts to throw the shoes out of contact with the driven shaft



thus disengaging the driving connection. When the driving shaft speed returns to or drops below the preset value, the shoes re-engage to provide a power connection. Motion of the clutch shoes is controlled by means of studs, fixed to the clutch casings, which permit radial but limit axial movements. *Patent 2,668,611 assigned to Birtman Electric Co., by C. H. Sparklin.*

Directional control of power transmission is achieved with a dual clutch assembly employing



two overrunning clutches mounted as a single unit. Operation of the clutches is controlled by the direction of rotation of a common drive shaft. With the

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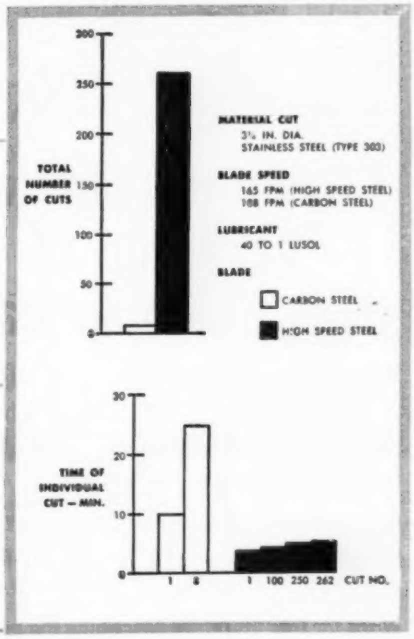
Moly tool steels

the part	**BAND SAWS**
the problem	Carbon-steel band-saw blades are usually made of a tool steel with about 1.25% C. For normal usage band saws make smoother and straighter cuts than hack saws. However, normal band saws run into difficulties when they're used as cut-off saws for materials with different machining properties.
the pay-off	The Henry G. Thompson & Son Company developed a moly high-speed steel, cut-off band-saw blade for stainless steel and other materials on a production basis. The chart shows graphically the results: cutting life of saw increased, time per cut shortened.



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Write for free literature describing the investment casting process.

CASE STUDY

DESIGNATION: Female Hinge

METAL USED: Stainless Steel (AISI 302)

QUALITY CONTROL: Chemical and physical affidavits furnished. Test Bars submitted. Produced with 100% X-Ray requirements.

PARTS: Designed and cast as single unit. Formerly composed of three units welded together.

ADVANTAGES: Strengthened with re-inforcing ribs in U-Bracket. Weight decreased without decrease in strength. Reaming holes only machining required. Formerly holes countersunk outer sides only, now cast with radii on both inner and outer sides. Greatly reduced cost.

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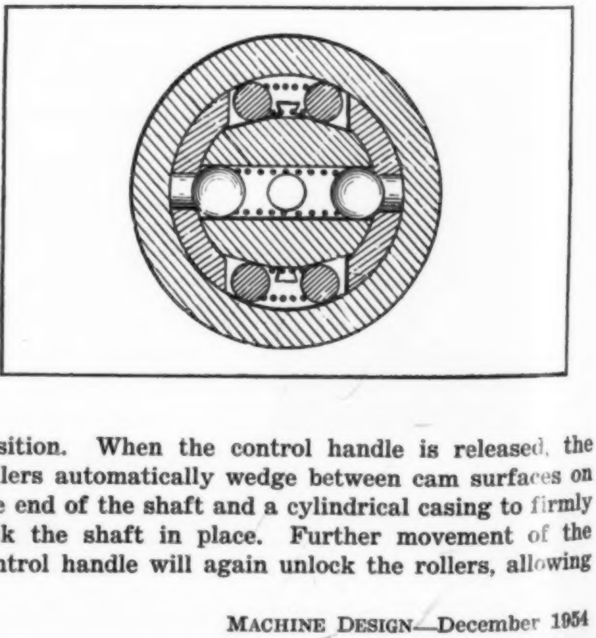
shaft rotating in one direction, one of the clutches is engaged while the other is inoperative. Changing the direction of shaft rotation reverses the functions of the clutches. Employed with a double gear train on a traversing mechanism, the device has been utilized to advantage to provide a fast or slow traversing motion by merely reversing the direction of rotation of a manual crank. *Patent* 2,670,826 *assigned to the United States of America by G. W. H. Sussdorff and H. D. Goodnow.*

FLUID-TIGHT SEALING of antifriction shaft bearings is accomplished with a lubricant seal designed to operate effectively under out-of-true mounting conditions. Sealing action is provided by a molded plastic or rubber annular diaphragm which is clamped to the bearing outer race at its outer diameter and bonded to a spring-loaded graphite wear ring, engaging the inner race, at its inner diameter. Variations in the engaging surface due to the bearing being out of true are taken up by the spring action rather than the resilience of the diaphragm. Rotational stresses in the diaphragm have been reduced by holding the wear ring contact surface to a minimum. Designed to be mounted as a single unit, the seal facilitates assembly and maintenance. *Patent* 2,674,473 *assigned to Master Electric Co. by A. F. Berger.*

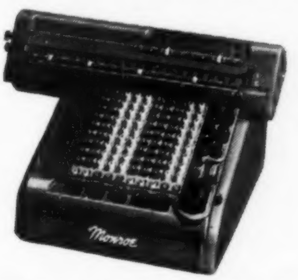
VIBRATION-RESISTANT ADJUSTMENT of angular lever movements in a manual control mechanism is provided by a roller and cam braking arrangement that automatically locks in position. A rocking motion imparted to the control handle acts to release wedged brake rollers, permitting a shaft connected to the unit to be controlled to be rotated to any desired



position. When the control handle is released, the rollers automatically wedge between cam surfaces on the end of the shaft and a cylindrical casing to firmly lock the shaft in place. Further movement of the control handle will again unlock the rollers, allowing

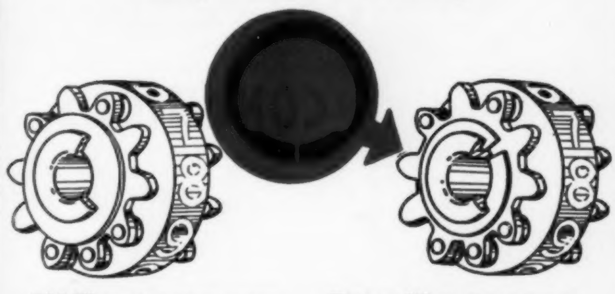
Waldes Truarc rings replace old-fashioned fasteners...save assembly time...end scrap loss...increase operating efficiency

This is the Monroe Calculator



...precision-engineered business machine made even more efficient, and less costly to manufacture through the use of Waldes Truarc Retaining Rings.

Multiplier Dial Assembly



Old Way. One-piece assembly was spun together. Spinning operation was costly, resulted in high scrap loss.

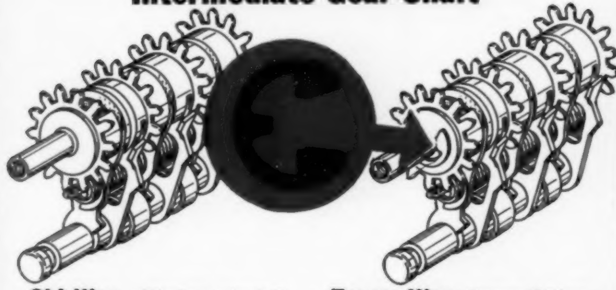
Truarc Way. Two-piece assembly is held together by one Truarc Ring (series 5108). Rejects: practically zero.

Electric Motor Governor

Old Way. Collector Disc assembly was formerly riveted, requiring skilled labor. Riveted Collector Disc could not be removed in the field.

Truarc Way. Truarc Ring (series 5100) replaces rivets, saves labor, material...improves Collector action. Collector Disc is easily replaced.

Intermediate Gear Shaft



Old Way. Washer riveted on end of assembly for zoning control. Costly, troublesome, hard to obtain critical zoning required.

Truarc Way. Truarc E-Ring (series 5133) cuts assembly time, virtually eliminates rejects and final assembly and zoning problems.

Monroe Calculating Machine Company, Orange, N. J. uses various types and sizes of Waldes Truarc Retaining Rings. Use of Truarc has helped eliminate scrap losses, saved on material and labor, and resulted in increased operating and servicing efficiency of the product. Monroe plans to use Truarc Rings for every possible fastening operation on their entire line!

You, too, can save money with Truarc Rings. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better, more economical job. Waldes Truarc Rings are precision-engineered...quick and easy to assemble and disassemble.

Find out what Waldes Truarc Retaining Rings can do for you. Send your blueprints to Waldes Truarc Engineers for individual attention, without obligation.

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For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

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TRUARC

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RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,392,947; 2,392,948; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,509 081 AND OTHER PATENTS PENDING

MD 126

Waldes Kohinoor, Inc., 47-16 Austel Pl., L. I. C. 1, N.Y.

Please send me the new Waldes Truarc Retaining Ring catalog.

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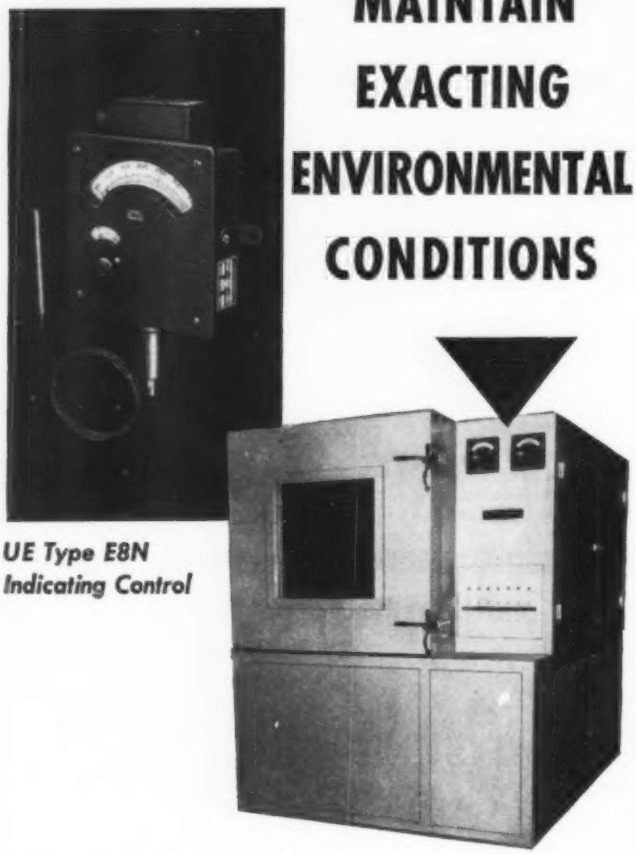
INDICATING CONTROLS MAINTAIN EXACTING ENVIRONMENTAL CONDITIONS



UE Type E8N Indicating Control

The temperature-humidity chambers made by Tenney Engineering, Inc., are widely used in testing resistance to moisture and corrosion, and in determining durability. They are also used in observing animal and plant life for changes caused by climatic conditions.

In these units, two United Electric Type E8N Indicating Controls accurately indicate and maintain simulated climatic conditions over wide temperature ranges. By simply resetting these controls, a new atmospheric equilibrium can be established in the chambers within 10 to 15 minutes.

United Electric manufactures many other temperature and pressure controls for use on environmental test chambers as well as for such varied applications as oil refinery and pipe line machinery, turbines and engines, aircraft, ovens and air conditioning equipment.

Special controls can either be adapted from standard models, or custom-built by United engineers working in cooperation with your own product development engineers.

Write today for information on the complete line of United Electric controls.

Standard and special temperature and pressure controls

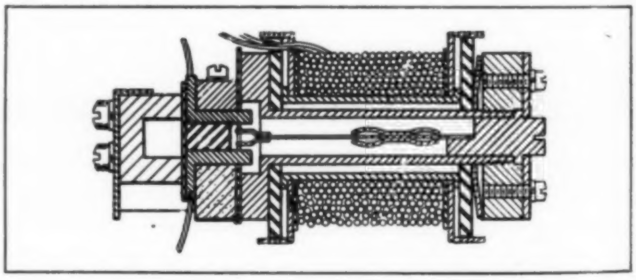
UNITED ELECTRIC CONTROLS CO.

92 School Street, Watertown, Mass.

the control mechanism to be readjusted to meet different application requirements. *Patent* 2,670,824 *assigned to New Products Corp. by O. H. Banker.*

FRICTION-RETAINED HUBS for small shaft assemblies eliminate set screws and keyways and other shaft discontinuities. Clamping action is obtained through resilient wedge shaped fingers which lie along the surface of the shaft and are mounted at the thick end to the hub flange. Pressure is applied to the tapered backs of the fingers through a clamping ring with a tapered inner edge. Position of the clamping ring is controlled by adjusting bolts; as the bolts are tightened, the ring moves toward the hub and wedges the clamping fingers against the shaft to provide a locking action. Assembly and maintenance are simplified by the design which permits the hub to be readily removed or shifted without shaft alterations. *Patent* 2,669,471 *assigned to Utility Appliance Corp. by B. B. Breslow.*

MAGNETIC SWITCH for high or low-speed current interruption operates at the frequency of an applied alternating current. Switching rates varying from 2 to 800 cps have been achieved. In operation, an alternating current is applied to a moving electromagnetic armature, producing an alternating magnetic field which magnetizes the armature contacts to opposite polarities at the frequency of the applied

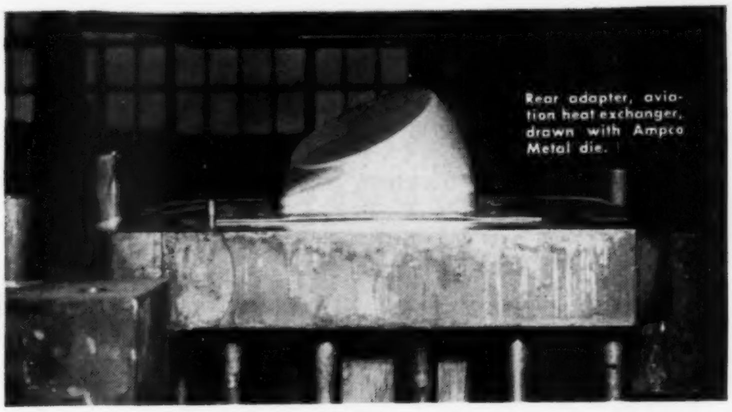


current. This polarity variation causes the armature contacts to be alternately attracted and repulsed by a set of stationary contacts of fixed magnetic polarity, thus making and breaking the switch contact at the applied ac frequency. Contact jumping or bouncing is prevented by spring dampers which also facilitate adjustment of the armature for uniform make and break characteristics. *Patent* 2,675,440 *assigned to Stevens-Arnold Inc. by H. Reifel.*

Correction

In the "Noteworthy Patents" section of last month's issue, the sketches of a wobble-rod clutch and a stationary bellows seal shown on Pages 318 and 320 were inadvertently transposed.

Stewart-Warner solves difficult drawing job by using



Rear adapter, aviation heat exchanger, drawn with Ampco Metal die.

AMPCO* METAL

AMPCO Metal tackles another tough job — and keeps losses on this drawing operation to less than 1%, amounting to a saving of $11,000 per year. Such savings are not unusual when Ampco dies take over, because they can help you save these two important ways:

1. Ampco's unusually low coefficient of friction gives you freedom from galling, loading, scratches, die marks. You get a better product and lower scrap losses. You minimize costly finishing operations.
2. Little or no pickup means less downtime. That's why Ampco dies give production runs many times longer than conventional steel dies without redressing — why they save you money, reduce your costs.

But don't take our word for it. Ask the man who uses Ampco dies. See for yourself how he reduces costs, downtime — how he makes a better product.

Get all the facts on Ampco Metal — the special alloy that makes good where other metals fail. Contact your nearest Ampco field engineer or send the coupon. *Reg. U. S. Pat. Off.

Stewart-Warner Corp.
Indianapolis, Indiana

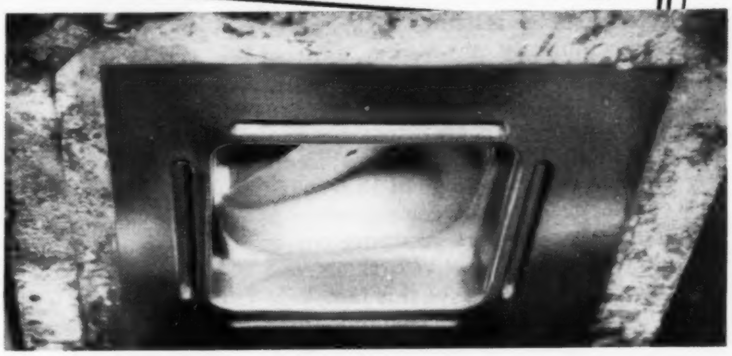
Product: Rear adapter, aviation heat exchanger.

Problem: Drawing .050" Inconel to make this rear adapter was a troublemaking operation — and an expensive one — for Stewart-Warner. The draw was deep — the shape complicated. Blanks were costly — $4.70 each. Other die materials failed. Spoilage was high — about 25% on a yearly production of 10,000 pieces.

Solution: AMPCO METAL, Grade 24, "Cast-to-shape"

Results: Losses on this drawing operation dropped to less than 1% when Ampco Metal Dies were employed. The high rate of spoilage on this operation is ended with an investment of less than $300 for Ampco dies.

IT'S PRODUCTION-WISE TO AMPCO-IZE



Top half of Ampco Metal die used for drawing rear adapter.

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Heavy-Duty Air-Cooled
ENGINES
3 to 36 H. P.

*Based on U. S. Bureau of Census Statistics, Wisconsin Motor Corporation leads the engine industry with 50.72% of total production in the 11 to 176 cu. in. displ. bracket — an industry-wide gain of 1.33%, as summarized below.

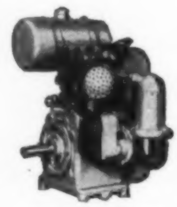
Once more U. S. Bureau of Census statistics provide authentic proof of outstanding preference for Wisconsin Heavy-Duty Air-Cooled Engines in the internal combustion engine field.

The latest "Facts for Industry" census report, released July 19, 1954, reveals the interesting fact that Wisconsin Motor Corporation produced 5,605 MORE engines in the 11 to 176 cu. in. displ. census grouping than ALL other internal combustion engine manufacturers combined, during 1953. This refers, of course, to engines built for re-sale, exclusive of automotive, aircraft, outboard, miniature and "captive" engines.

Translated into industry-wide percentages, census figures indicate that this company showed a gain of 1.33% over the combined production of all other engine builders. This, however, is an ultra-conservative figure inasmuch as the Wisconsin line covers a range of 13.5 to 154 cu. in. piston displacement whereas the Census Report grouping covers engines from 11 to 176 cu. in. displacement. In spite of this fact, Wisconsin Engine production amounted to 50.72% of the Industry's total in above grouping.

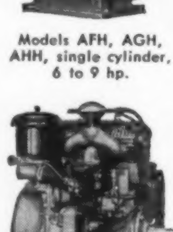
Statistically, these figures are interesting to us as evidence of consistent progress. To the Original Equipment Builder, Distributor and User of engine power, this report provides definite proof of INCREASED PREFERENCE for Wisconsin Heavy-Duty Air-Cooled Engines among people who are best qualified to judge comparative engine values in terms of performance, economy and low-cost maintenance.

You can't go wrong if you specify WISCONSIN Engines for the equipment lines you *sell*, *build* or *use*.



Models ABN, AKN, AEN, 4-cy. single cyl., 3 to 8¼ hp.

Models AFH, AGH, AHH, single cylinder, 6 to 9 hp.



Models TE, TF, TFD 2-cylinder, 7 to 15 hp.

Models VE4, VF4, and VG4D, V-type 4-cyl., 15 to 36 hp.

MOST H.P. HOURS

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

New Machines

Materials Handling

Transfer Conveyor: Model 1600 transfer conveyor feeds cylindrical work to centerless grinders, polishing or inspection machines. Feed rate is controlled by a variable-speed drive, and a range of 7 to 28 fpm is available on the standard unit. Typical work range is ¼ to 1½ in. diameter. Standard unit is 60 in. overall; models are available for other diameters and lengths. Self-contained unit is powered by ¼-hp, 220/440 v, three-phase motor. *Feedall Machine & Engineering Co., Willoughby, O.*

Air Hoist: Air hoist with 150-lb capacity permits operator to raise or lower load and swing it into position with one hand. Full-range speed control provides for raising or lowering at any rate up to 40 fpm through a 9-ft lifting range. Hoist is built for continuous service; overloading cannot overheat or burn out the motor. Suspended by its cable from any overhead support, lightweight hoist is easily pulled down for use. It weighs 14 lb. *Keller Tool Co., Grand Haven, Mich.*

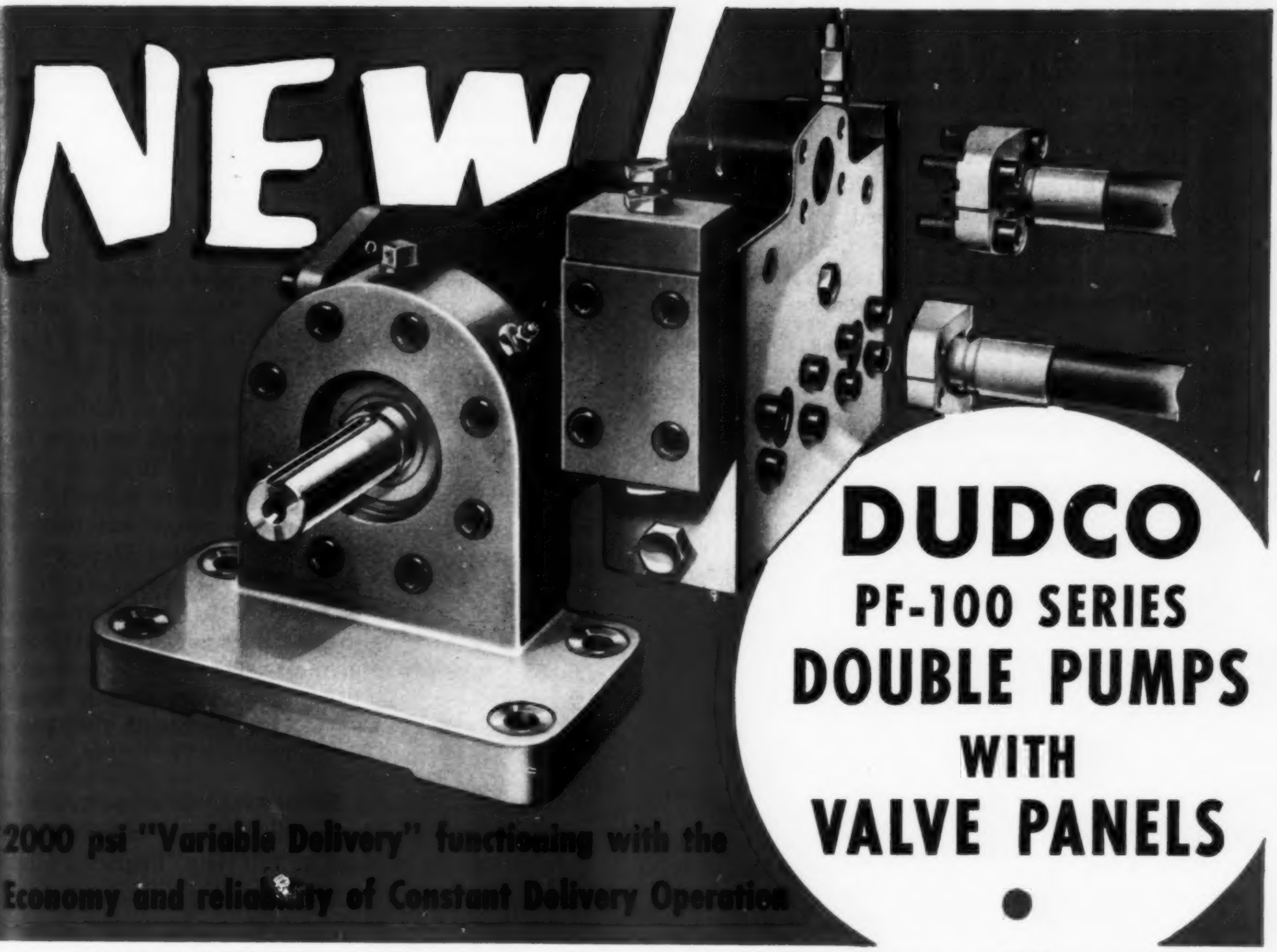
Portable Loading Dock: Battery or ac-powered hydraulic elevating mechanism of portable loading dock will raise 6000-lb loads up to a maximum height of 56 in. Loading and unloading trucks from ground level is facilitated by employing a hand truck along with the dock. Unit, which can be handled by two men, folds for storage. *Raymond Corp., Greene, N. Y.*

Side-Loading Fork Truck: Redesigned model T-10-A side-loading Traveloader has a torque converter drive and four-wheel springing. Lifting capacity is 10,000 lb; standard lifting height is 144 in. Maximum travel speed forward is 30 mph; reverse, 15 mph. Turning radius is 22 ft, 7 in. *Baker-Raulang Co., Cleveland, O.*

Metalworking

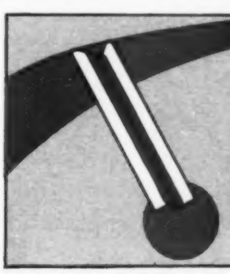
Welder: SLP ac type welder for heavy duty is available in 300, 400 and 500 amp sizes. Transformer is shell type and uses "Saturable Leakage Path" control for adjustment of welding current. An extra secondary winding supplies current to the control rectifier, which is of standard selenium type, operating on 40 v dc for safe, low-voltage remote control. No high voltage is produced across any control coils. Control is sensitive to a wide range of welding conditions and highly responsive to changing arc conditions so that machine can weld both light and heavy metals. Three-wheeled portable mounting equipment is optional. *Hobart Brothers Co., Troy, O.*

Horizontal Disk Grinder: Intended for quick freehand grinding of a single flat surface on many small



DUDCO PF-100 Series Double Pumps with Valve Panels are versatile. They furnish *Fluid Power*, at continuous pressures to 2000 psi, either to two separate systems or to a single two-pressure circuit, controlled automatically in response to working pressures or remotely thru a pilot line.

DUDCO PF-100 Series Double Pumps with Valve Panels assure top system economy. They can be installed with almost "plug-in" ease. The Valve Panel contains the elements necessary for pressure regulation and flow control . . . valves, piping and connections in a system are reduced.



TWO VANES ARE BETTER THAN ONE!

The hydraulically balanced DUAL-VANES in DUDCO Hydraulic Pumps as contrasted with conventional designs, maintain MULTIPLE AREAS OF CONTACT ON THE CAM RING . . . doubling the number of effective barriers to slippage and power loss. This patented principle is an exclusive DUDCO feature!

DUDCO Hydraulically Balanced, Dual-Vane Design Pumps give long, maintenance-free service at all pressures up to 2000 psi; with cost equal to that of low pressure pumps.

DUDCO PF-100 Series Double Pumps with Valve Panels insure maximum circuit efficiency . . . only fluid required for effective circuit operation is pressurized. Wasteful by-passing of unneeded fluid is eliminated . . . horsepower is saved and fluid heating reduced. The regulator valves are internally piloted . . . this superior design allows more accurate adjustment and provides better control over a wider pressure range without the danger of spool sticking or over-pressurization.

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I would like more information about the DUDCO PF-100 Series Double Pumps with Valve Panels. Please send me Bulletin No. DP-308.

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parts, new horizontal disk grinder has vertical spindle which carries the 18-in. diameter grinding wheel. Spindle is mounted in antifriction bearings and is driven through multiple V-belts from a 5-hp motor. Mounted on a hinged plate to facilitate belt adjustment, motor is completely enclosed, as is drive. A hand-operated bar type dresser is provided, and an outlet for attaching a dust collecting system is built into base of machine. *Gardner Machine Co., Beloit, Wis.*

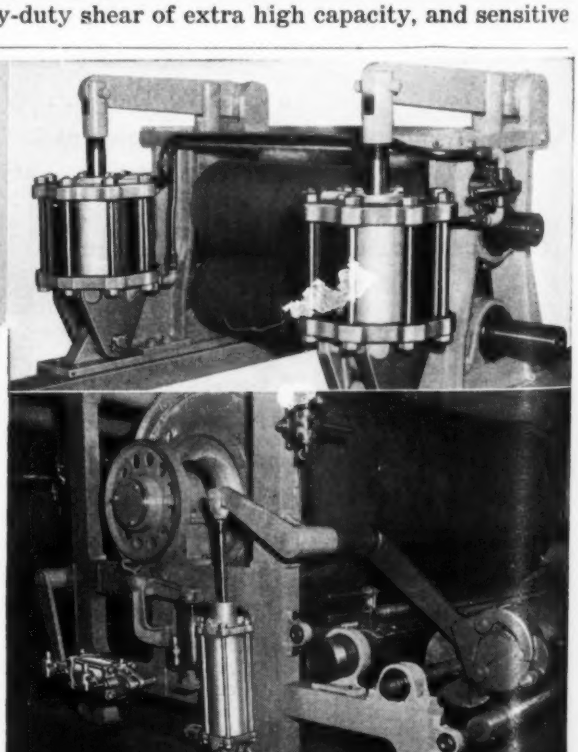
Drill Unit: Drilling, reaming, spot-facing, chamfering, tapping, threading and hollow milling can be done by model 34 Holomatic air-hydraulic drill unit. This drill has self-contained electric motor-pulley drive system designed to use either Timing belt or V-belt drives for power transmission from the motor to the spindle. Spindle speeds from 300 to 10,000 rpm are made possible by the interchange of pulleys and motors. Motors of ½, ¾, 1, 1½ and 2 hp are available. An automatic hydraulic oil-filling system maintains oil level in the hydraulic section. Torque capacity is 200 lb-in. Stroke is adjustable to 4 in. Depth accuracies to 0.0005-in. can be maintained by use of positive stop and dwell. Unit operates on 50 to 150 psi air pressure. *Hause Engineering, Montpelier, O.*

Lathes: All-geared head, Tray-Top lathes in 21½ and 26-in. sizes have 12 spindle speeds in geometric progression, with a three-lever, direct-reading shift mechanism. Spindle, with long taper key drive nose, is rigidly mounted in three precision antifriction bearings. An extra-large spindle hole is available. All headstock bearings are pressure-lubricated with filtered oil. Totally enclosed, automatically lubricated quick-change gear box provides 54 thread and feed changes and also incorporates a lever to reverse the leadscrew. Apron is a one-piece double-walled casting with automatic lubrication. Longitudinal and cross feeds are engaged with drop levers operating positive jaw clutches, and a spindle start-stop control lever is supplied at the apron and quick-change box. Lathes are offered with 5 or 7½-hp motor mounted on the rear of the headstock. *Cincinnati Lathe & Tool Co., Cincinnati, O.*

Adjustable Bar Folder: For bending or folding sheet metal to an angle or lock, new machine operates from compressed air at pressures from 70 to 80 psi. Foot-operated valve controls flow of air to actuating cylinder. Initial movement of the piston automatically clamps work in place while the folding blade rotates. Release of the pedal instantly reverses action. An adjustable stop limits the bend to the desired angle. Width of fold is controlled by easily regulated gage. Machines are available in four sizes to handle working lengths from 21 to 42 in. and thicknesses of 20 gage mild steel and lighter. *Niagara Machine & Tool Works, Buffalo, N. Y.*

Extrusion Press: Horizontal, direct-powered extrusion press for aluminum, brass or copper shapes, bars and tubes is rated at 750 tons. Features include fast cycling, positive billet loading, easy die change, heavy-duty shear of extra high capacity, and sensitive

CLOTH-FINISHING MACHINES ...employ NOPAK Cylinders to Raise and Lower Rollers



The David Gessner Company, Worcester, Mass., manufacturers of modern cloth finishing equipment, employs NOPAK Air Cylinders in its sizing machines to raise and lower heavy rollers, and, in some cases, to equalize roller pressures. The examples pictured may suggest how you, too, can use NOPAK Cylinders, controlled by NOPAK Operating Valves, to build accurate, simplified machine movements into your plant equipment, or into machinery that you manufacture for resale.

The NOPAK Application Manual shows you how NOPAK Valves and Cylinders are being used in all types of industry, in many types of machinery and equipment for pulling, pushing, lifting, lowering, clamping, positioning. If you haven't seen a copy, ask your NOPAK representative, or write.

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DESIGN and PRODUCTION NEWS

FOR DESIGN AND MATERIALS ENGINEERS

Published by TECHNICAL SERVICE, Chemical Manufacturing Division, The M. W. KELLOGG Company DECEMBER 1954

Insulator of KEL-F® Plastic Doubles as Vital Structural Part in Severe 250°F Water-Immersion Service

Perfect electrical insulation and maintenance of critical spacing of electrodes are provided by this spacer of KEL-F polymer plastic. Even under constant immersion in water at 250°F, insulation remains high, precision tolerances and dimensions of the spacer-insulator are maintained.

Excellent mechanical properties of this fluorocarbon plastic dielectric under extremes of temperature and stress permit the critical spacer to be used under heavy spring loading without deformation or failure. Accurately machined grooves in the plastic hold O rings to prevent liquid leakage.

McNab Incorporated, New York City, machines the spacers from rod extruded from unplasticized KEL-F polymer by the Resistoflex Corporation, Belleville, N. J.

For further information ask for Application Report E-131

For complete information regarding any item mentioned in DESIGN AND PRODUCTION NEWS, ask for detailed APPLICATION REPORTS, write

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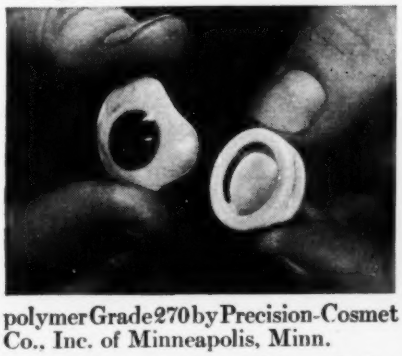
Prosthetic Eye Implants are Permanent—Non-Irritating to Living Tissue, They Retain Shape Indefinitely

Elimination of the necessity for periodic removal of prosthetic eye implants for replacement or "re-sizing" is the major advantage claimed for implants made from KEL-F polymer plastic. Once "fitted" to the individual eye socket, the implant retains its original size and shape, does not shrink or swell to cause pain to the wearer. The plastic's heat and moisture resistance allow it to be steam sterilized.

Since the fluorocarbon plastic is chemically inert, it does not cause irritation to adjacent sensitive tissues.

The plastic implant, known as the "Allen", is custom made from KEL-F polymer Grade 270 by Precision-Cosmet Co., Inc. of Minneapolis, Minn.



For further information ask for Application Report P-103

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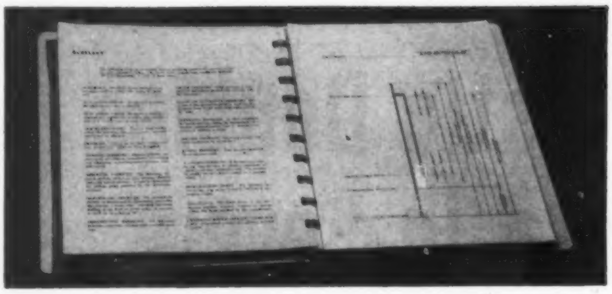

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As an aid in planning the vital link between your electric and hydraulic circuits, this manual contains a glossary of terms and a schematic demonstration of operating characteristics. Functions and methods are described in detail and liberally clarified with diagrams and illustrations, including symbols for circuit detailing and specification purposes. To provide the means for proper selection of a pressure switch for your specific application, a simple step by step selection chart has been developed helping you to organize your requirements in their relative order. Finally a complete run-down, illustration and tabulation of all the detail features leading to the unit that answers your specific control problem. You couldn't buy a comparable handbook.

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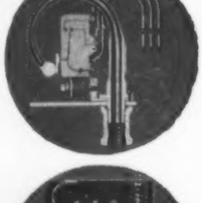

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ALL SWITCHES operate in any position, are not sensitive to vibration.

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control of the main ram. Press will extrude solid strips, rod and hollow or semi-hollow sections from a preheated aluminum, brass, copper or magnesium billet 4 7/16 in. in diameter. Recommended uses include light metal parts and ornamental trim. *Sutton Engineering Co., Bellefonte, Pa.*

Plant Equipment

Centrifugal Blower: Multistage, standard-production centrifugal blower delivers air volumes between 1500 and 5000 cfm, with pressures ranging from 1 to 9 psi or vacuum from 2 to 12 in. of mercury. Using a combination of two interchangeable impellers, the series 385 blower can be factory assembled to specifications. Units are self-adapting to any variation in air volume requirements from minimum to maximum capacity. Rotating element is dynamically balanced to prevent vibration, providing continuous, 24-hour-a-day operation without adjustment. *Air Appliance Div., U. S. Hoffman Machinery Corp., New York, N. Y.*

Compact Filter: Sel-Rex filter can be used with either standard porous stone elements or a new type stainless steel element. Double filtration area and volume is effected by use of the new filter element, constructed of corrugated stainless steel and wire mesh, which supports a filter bag. Furnished in a variety of cloth materials, the bag type element is suitable for use with any solution or liquid. Entire filter element is attached to the cover of the tank and is easily removable for quick inspection, cleaning or replacement. All models have large-capacity stainless steel precoat tank, to make precoating a one-step operation. Portable and stationary models are available for both acid and alkaline solutions. Standard portable models have up to 20 sq ft of filtration area and capacity of 2000 gph; standard stationary models have up to 175 sq ft of filtration area and capacity of 18,000 gph. *Bart-Messing Corp., Belleville, N. J.*

Woodworking

Electric Sander: Model 700 vibrator type sander provides 25 sq in. of sanding area. Vibrating at 14,400 strokes per minute from a 60-cycle reciprocating motor, machine sands with the grain of the wood to produce smooth, scratchless surfaces. Rubber insulators between plastic housing and motor provide smooth and quiet operation. Pressure can be exerted on sander to speed removal of wood. *Weller Electric Corp., Easton, Pa.*

Power Tool Workshop: Power tools with "quick-change" motor mount attachment permit use of one motor to operate any number of tools. Changeover time is 10 seconds. Workshop is composed of 8-in. tilting arbor saw, 4½-in. jointer, 15-in. jig saw, 14-in. drill press and 27-in. gap lathe, each equipped with its own mounting bracket and belt tension rack. The motor has an attached motor mounting rail which fits onto the tool bracket and locks automatically. Other tools available with same motor mounting include 10-in. bandsaw, 6-in. sander, 10 by 31-in. lathe and 5 and 6-in. jointers. *Duro Metal Products Co., Chicago, Ill.*

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C/R Type W Oil Seal with Sirvene sealing element as applied to automotive passenger car Pinion Bearing. Note slinger arrangement for exclusion of extraneous matter.

EXPERIENCE MAKES THE DIFFERENCE

Chicago Rawhide brings the world's widest experience to any oil sealing problem . . . and unequalled resources of research, engineering and production. C/R's specialized sealing materials include Sirvene synthetic rubber . . . Sirvis mechanical leather . . . and the new **Conpor** leather (which gives complete lubricant control). Each of these materials offers special advantages for a wide range of applications under varying operating conditions. Chicago Rawhide engineers will be glad to work with you in developing the right material for your problem and cooperate on special designs. Or, you may be able to select the right C/R seal from 17 standard types and more than 1800 sizes. Write us, if you would like a copy of "C/R Perfect Oil Seals".

C/R

PERFECT

Oil Seals

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device

CHICAGO RAWHIDE MANUFACTURING COMPANY

1301 Elston Avenue OIL SEAL DIVISION Chicago 22, Illinois

Representatives in these Principal Cities: Boston • New York • Syracuse • Buffalo • Philadelphia • Pittsburgh • Cincinnati • Cleveland Detroit • Peoria • Minneapolis • Wichita • Tulsa • Houston • Los Angeles • San Francisco • Seattle • Spokane • Portland

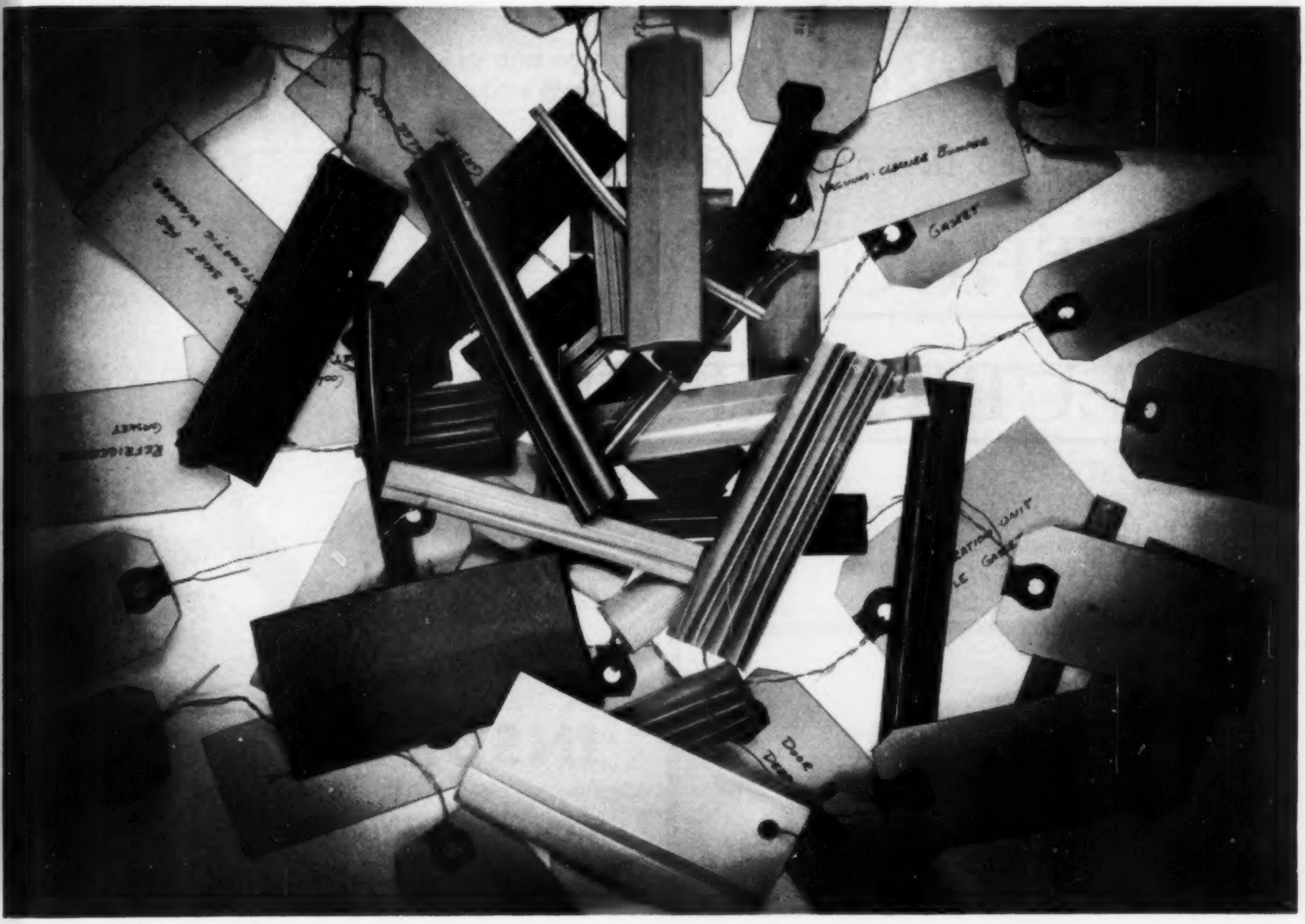
MANUFACTURED AND DISTRIBUTED IN CANADA BY SUPER OIL SEAL MFG. CO., LTD., HAMILTON, ONT.

Other **C/R** *products*

Sirvene: (Synthetic rubber) diaphragms, boots, gaskets and similar parts for critical operating conditions • Conpor: Controlled porosity mechanical leather packings and other sealing products • Sirvis: Mechanical leather boots, gaskets, packings and related products.

Capture Color-Conscious Consumers

with custom extruded vinyl compounds



SHAPES OF THINGS THAT CAME to the aid of manufacturers seeking to increase the salability of their products are these attractively colored samples of functional, durable vinyl extrusions from Goodyear, St. Marys.

THE modern way to sell is with color. And many manufacturers—automotive, appliance and furniture, in particular—are meeting this consumer demand with colorful, durable vinyl extrusions. You can do the same—easily and economically—with the help of Goodyear and its recently expanded facilities at its big, modern molded and extruded goods plant in St. Marys, Ohio.

An unlimited range of colors—transparent, translucent or opaque—natural or metallic—is now readily available in unlimited cross-sectional design, unlimited lengths and unlimited quantities. Other outstanding properties include: A wide range in hardness. High strength. Excellent abrasion-, oil- and chemical-resistance. Low taste and odor levels. And again, low temperature and electrical properties comparable or superior to those of rubber.

Most important, however, are the services and skills awaiting your call at St. Marys. An expert group of engineers, compounders and production workers is ready, willing and able to help you improve the sales appeal of your product with quality vinyl extrusions turned out with the finest equipment available. Details? Design assistance? Just write: Goodyear, Industrial Products Division, St. Marys, Ohio or Akron 16, Ohio.

GOODYEAR

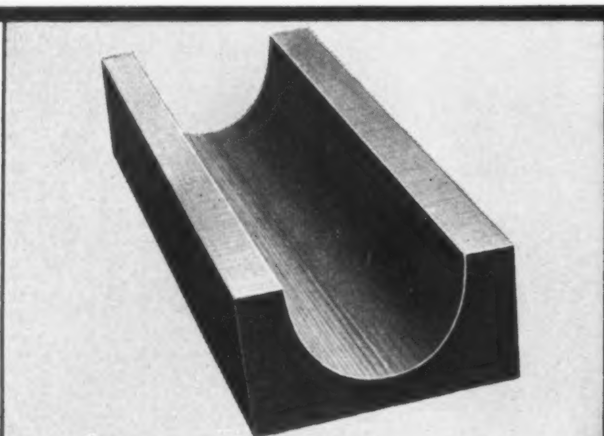
THE GREATEST NAME IN RUBBER

We think you'll like THE GOODYEAR TELEVISION PLAYHOUSE—every other Sunday—NBC TV Network

this graphitized plastic bearing

MAY BE USED IN SOME APPLICATIONS

WITHOUT LUBRICATION



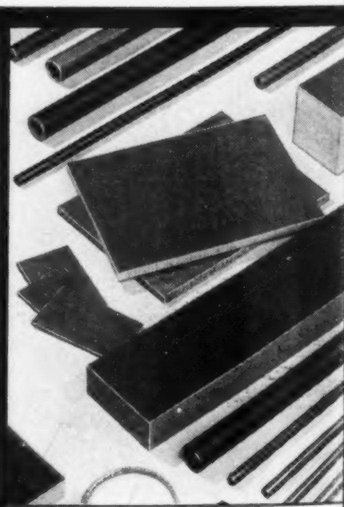
INSUROK® T-602

is ideal where lubrication is difficult. Eliminates oil or grease contamination.

Here is a graphitized plastic laminate that is excellent for many bearing applications where speed, load, and frictional heat are low. In such cases no lubrication may be required. In other applications of heavy load and high speed, where frictional heat will develop, this bearing can be lubricated and cooled with water or other non-corrosive fluids, thus avoiding the danger of staining or contamination from oil or grease.

Bearings made from INSUROK T-602 are especially recommended for intermittent and moderate speed applications. When adequately cooled they can sustain high speeds and heavy loads, and frequently will last much longer than metal bearings.

INSUROK T-602 has a low coefficient of friction and high resistance to wear and abrasion. It resists deformation under pressure—will not "forge" out under impact, and stands up in many applications where metals fail. INSUROK T-602 can be machined on ordinary equipment. Investigate INSUROK T-602 for your bearing applications.



AVAILABLE IN SHEETS, RODS OR TUBES

The RICHARDSON COMPANY

FOUNDED 1858

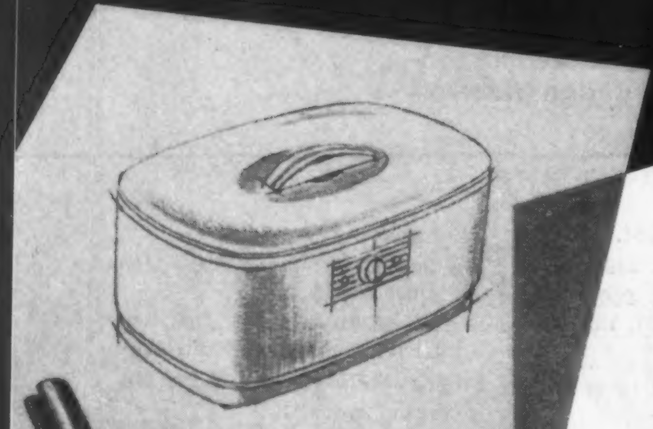
2795 Lake Street, Melrose Park, Illinois (Chicago District)

SALES OFFICES IN PRINCIPAL CITIES

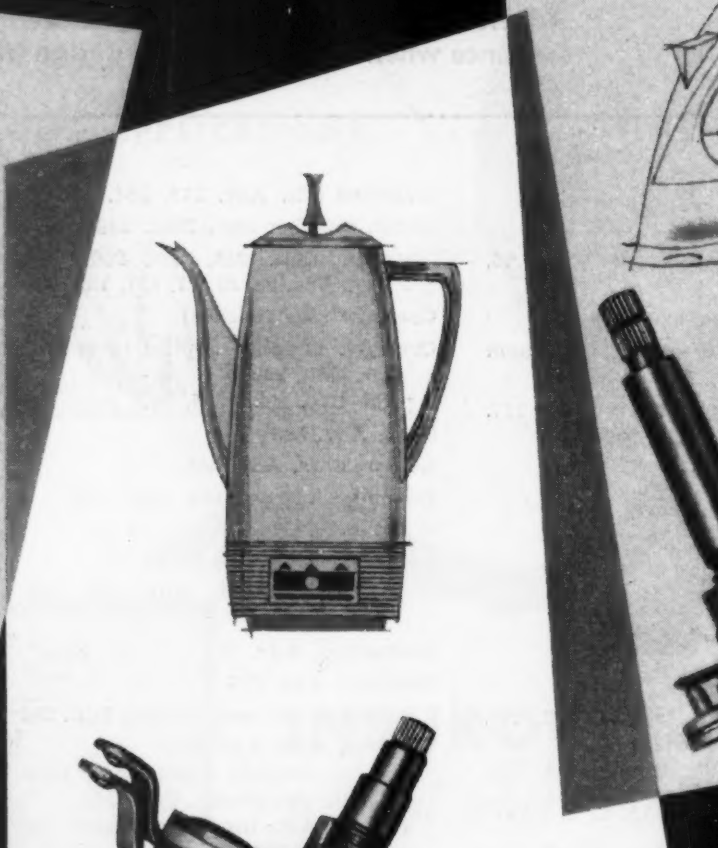
INDEX

Advertising and editorial content itemized for convenience when studying specific design problems

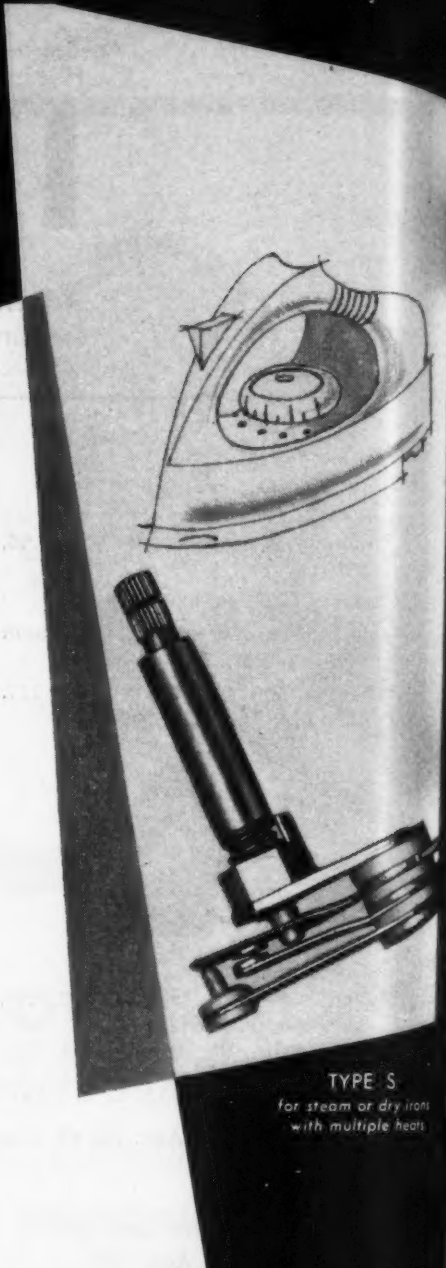
(*Concluded on Page* 10)



TYPE R
for portable roasters



TYPE SA
for automatic percolators



TYPE S
for steam or dry irons with multiple heats

THERMOSTATS

to whet a designer's imagination . . .

With competitive conditions ahead, you're probably reappraising your product. Or designing a new one. Either way, with Stemco thermostats on the job there's every chance you'll improve performance . . . solve production headaches . . . lower costs.

No other line of bimetal thermostats has as many different styles in production. So if you want close control, compactness, light weight— you'll find them all in Stemco thermostats. Combined with Stevens application engineering service, you profit from important savings of being able to use a production line Stemco thermostat for your special needs.

Let's match our experience and enthusiasm against an hour of your time. A card or call will bring our representative on the double.

STEMCO thermostats

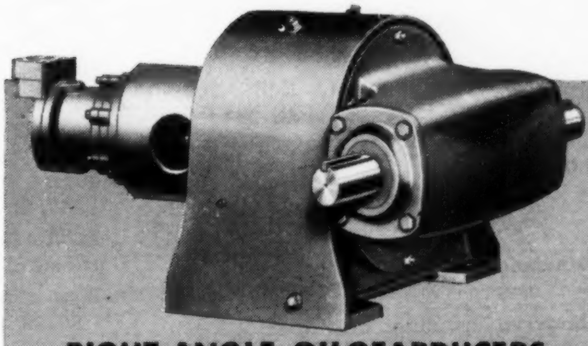
sensitive · close control
quick acting · positive acting
snap acting · shock resistant
light · compact · adjustable
non-adjustable
open type
hermetically sealed

STEVENS manufacturing company, inc.
Mansfield, Ohio

NOW! NEW OILGEARDUCERS

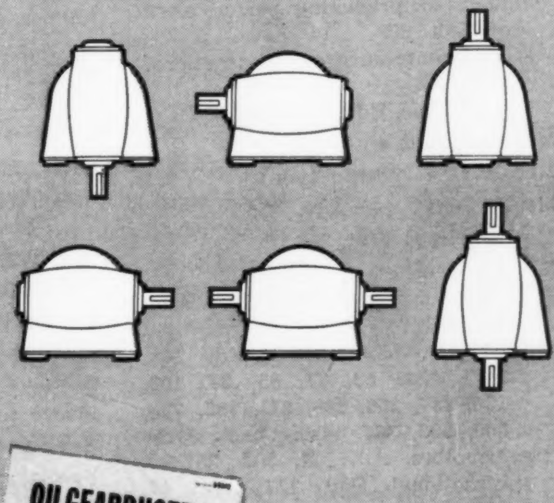
Offering for the first time compact, packaged, fluid power output drive units!

● Oilgearducers are new integral output drive units combining Oilgear Fluid Power axial piston motors and Falk All-Steel Reducers. There are horizontal and vertical models, concentric and right angle types and single, double, triple and quadruple reduction. Now, for the first time you can get a complete, easy to install, "ANY-SPEED" output unit for your high torque, low maximum speed drives. When used in combination with Oilgear Fluid Power Pumps, these reversible Oilgearducers provide infinite variability of speed, absolutely controlled rate of acceleration and deceleration, smooth and swift reversal, cushioned braking. All these together with major economies in motor, circuitry and power requirements. This new Oilgearducer "Any-Speed" output unit is available in sizes from 1 to 20 h.p. It is unequalled for applications as diverse as can-filling, paper machines, centrifugals, cable wrappers . . . and in automation or feed back applications where synchronization is an absolute necessity. Write now for new bulletin 56610. THE OILGEAR COMPANY, 1568 West Pierce Street, Milwaukee 4, Wisconsin.



RIGHT ANGLE OILGEARDUCERS

Oilgearducers with right angle output shafts are available in ratios ranging from 5 to 1500: 1. In assemblies shown below.



OILGEAR

PIONEERS...NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS & VALVES

Write for this new Bulletin 56610

INDEX

(Concluded from Page 7)

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

ELECTRICAL CONDUIT

PERMANENT
EASILY INSTALLED
LIQUID-TIGHT
FLEXIBLE
APPROVED

SEALTITE (TYPE U.A.) is approved by Underwriters' Laboratories, Inc. for use where exposed to moisture or mineral oils (up to 60C). The N.E. Code, Art. 351.

SEALTITE

ELECTRICAL CONDUIT PROTECTS WIRING

against oil, grease, water, dirt, chemicals, corrosive fumes, salt spray, weather

SEALTITE* is a flexible *and* liquid-tight electrical conduit. It gives maximum protection to your wiring when it must connect moving parts, absorb vibration, follow machine contours, flex into U-bends, be easily maintained or be safeguarded between misaligned ports.

It is being used successfully in wet locations, in tunnels, power plants, steel mills, canneries, chemical industries and in many outdoor applications. SEALTITE comes in two types:

TYPE U. A.—UL-approved. Made with flexible galvanized steel core, positive ground and tough outer cover.

NOM. I.D. (Inches)	INSIDE DIA. (Inches) Min.	INSIDE DIA. (Inches) Max.	OUTSIDE DIA. (Inches) Min.	OUTSIDE DIA. (Inches) Max.	APPROX. INSIDE BEND DIA. (Inches)	EST. WEIGHT per hundred ft. (Pounds)
3/8	.484	.504	.690	.710	8	30.0
1/2	.622	.642	.820	.840	10	36.6
3/4	.820	.840	1.030	1.050	15	48.2
1	1.041	1.066	1.290	1.315	18	87.7
1 1/4	1.380	1.410	1.630	1.660	21	116.5

TYPE E. F.† (Extra Flexible)—for machine tools and industrial equipment. (Meets standards set by J.I.C.) †Pat. Applied For

NOM. I.D. (Inches)	INSIDE DIA. (Inches) Min.	INSIDE DIA. (Inches) Max.	OUTSIDE DIA. (Inches) Min.	OUTSIDE DIA. (Inches) Max.	APPROX. INSIDE BEND DIA. (Inches)	EST. WEIGHT per hundred ft. (Pounds)
3/8	.485	.505	.690	.710	5	24.3
1/2	.620	.640	.820	.840	6	29.0
3/4	.815	.835	1.030	1.050	9	38.2
1	1.025	1.055	1.290	1.315	10	65.0
1 1/4	1.365	1.395	1.630	1.660	13	84.4
1 1/2	1.575	1.605	1.870	1.900	15	122.0
2	2.020	2.055	2.335	2.375	17	158.0
2 1/2	2.480	2.515	2.840	2.875	20	205.0
3	3.070	3.110	3.460	3.500	27	290.0
4	4.000	4.050	4.460	4.500	34	430.0

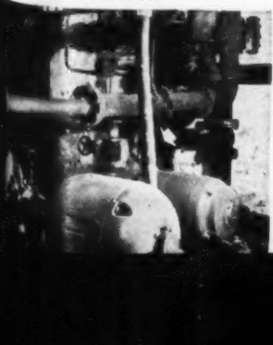
Commercial tolerances apply on above figures.

ELECTRICAL WHOLESALERS stock both types. Buy it in long random lengths as shown; then cut without waste. Or ask your wholesaler to cut the length you need. Liquid-tight connectors are available from wholesalers' stocks. Write for Bulletin UA-531. *The American Brass Company, American Metal Hose Branch, Waterbury 20, Conn.*

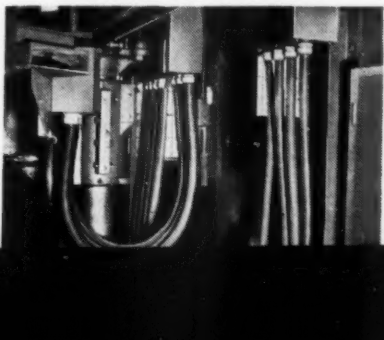
*Trade Mark 5417F

SEALTITE flexible, liquid-tight electrical conduit an ANACONDA® product

FOR WET SPOTS

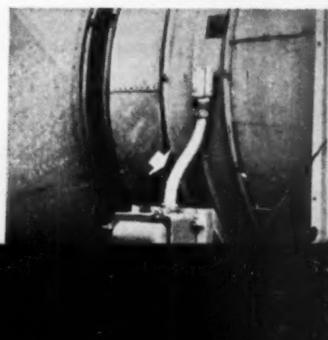


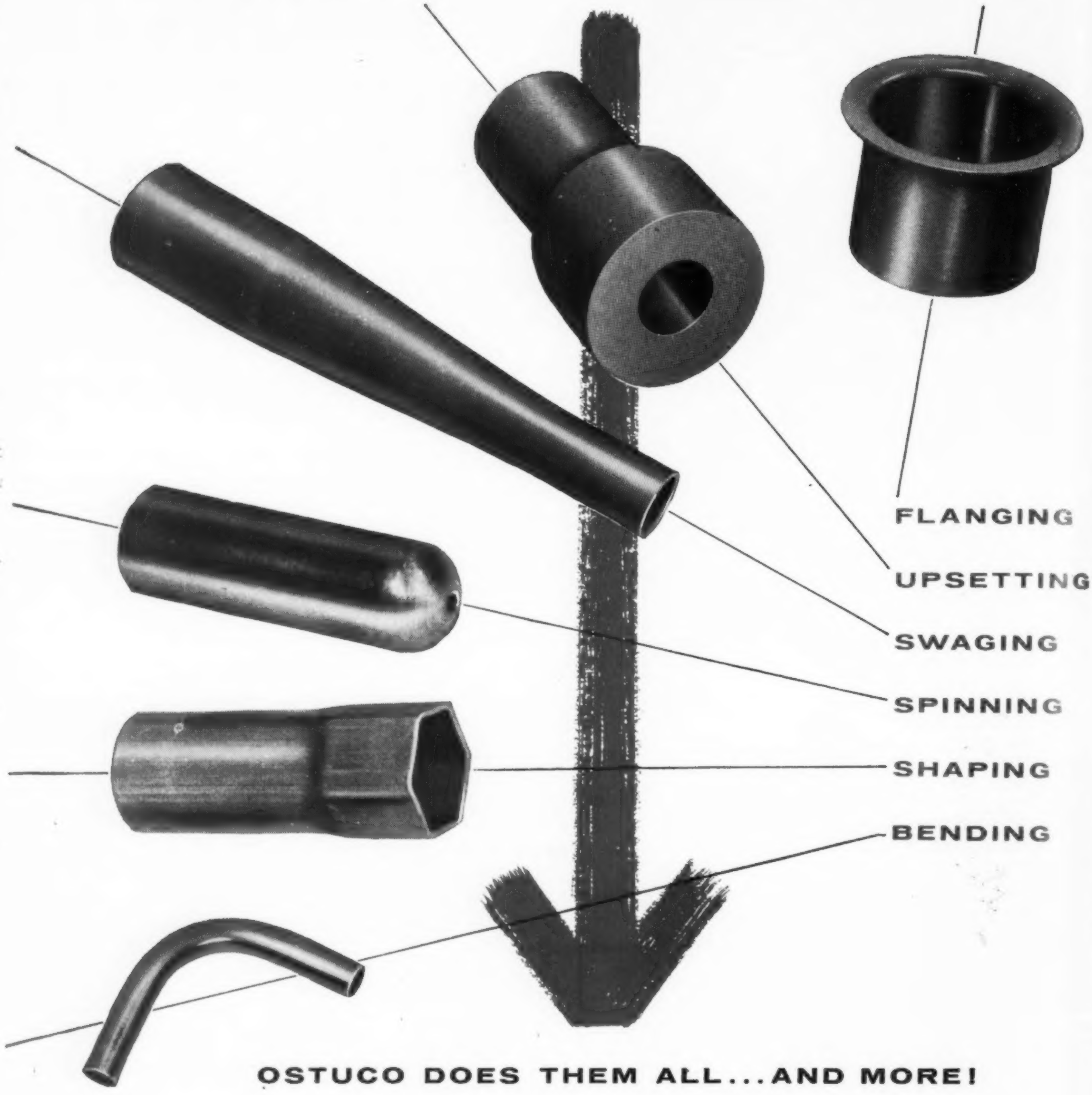
MOVING CONNECTIONS



OUTDOORS

MISALIGNMENT





OSTUCO DOES THEM ALL...AND MORE!

OSTUCO carbon or alloy steel tubing is manufactured, fabricated and forged to your exact specifications . . . *all under one roof.* If you want to know more about the advantages of a "single source" where one purchase order takes care of all details, send for our latest catalog, "OSTUCO Tubing." Better still, send us your blueprints for prompt quotation.

OSTUCO SHELBY, OHIO **OSTUCO TUBING**

SEAMLESS AND ELECTRIC WELDED STEEL TUBING —Fabricating and Forging

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • **SHELBY, OHIO**
Birthplace of the Seamless Steel Tube Industry in America

SALES REPRESENTATIVES: BIRMINGHAM • CHARLOTTE • CHICAGO CLEVELAND • DAYTON • DENVER • DETROIT (Ferndale) • HOUSTON • LOUISVILLE LOS ANGELES (Beverly Hills) • MOLINE • NEW YORK • NORTH KANSAS CITY PHILADELPHIA • PITTSBURGH • RICHMOND • ROCHESTER • ST. LOUIS • ST. PAUL SALT LAKE CITY • SAN FRANCISCO • SEATTLE • TULSA • WICHITA
CANADA, RAILWAY & POWER CORP., LTD.
EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY
117 Liberty Street, New York 6, New York


Small Gearmaking is a Fine Art at G.S.
G. S. has attained a degree of accuracy long considered impossible in the mass-manufacture of Small Gearing. Whether your needs run in hundreds or thousands, *each* Gear proves so uniformly accurate that rejects are no longer a problem.
Think of the time and money that saves . . in assembly work . . in returned goods . . in the greater satisfaction of your trade and your users. ★ The finer, more uniform quality of G. S. Gearing has been recognized for more than 38 years. But, never so highly valued as NOW! Increasingly competitive conditions demand *better* components . . better performance in *EVERY unit you produce.* ★ More and more manufacturers from coast-to-coast are turning to the extremely accurate Gearing we make. Let our capable staff work with you, too, on the very next order you place.
FRACTIONAL HORSEPOWER GEARING
GS
GEAR
Specialties, Inc.
2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS
SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS
OF FRACTIONAL HORSEPOWER GEARING
Gear Specialties
GEAR Specialties, Inc.
GET G.S. TECHNICAL DATA Free!
See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant views, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!

• Since 1867 engineers, scientists, designers, surveyors, draftsmen have relied on K&E as the foremost, most progressive, and most complete source of supply for the tools, equipment, and materials they work with. When you buy, think first of K&E, headquarters for 7,000 items. For example . . .

THE PARAGON® DRAFTING MACHINE

Thorough knowledge and thorough care of minutest detail were essential to the designing of the sturdy, accurate Paragon® Drafting Machine. Draftsmen prefer the Paragon, because it is time-saving and work-sparing, because it is reliable, easy to operate, and because they don't have to treat it with kid gloves. The Paragon Drafting Machine increases drafting room efficiency enormously, and effects substantial economies.

KEUFFEL & ESSER CO.

EST. 1867

New York • Hoboken, N. J.

Chicago • St. Louis • Detroit • San Francisco • Los Angeles • Montreal
Distributors in Principal Cities

Wearplates and Washers

with bearing properties. Bronze wearplates in many sizes and shapes, with precision-machined details . . . holes, slots, grooves, bevels or recesses. Washers of bronze, steel or bimetal combination. We specialize in standard and special bearing parts. Engineering service. Quality control.

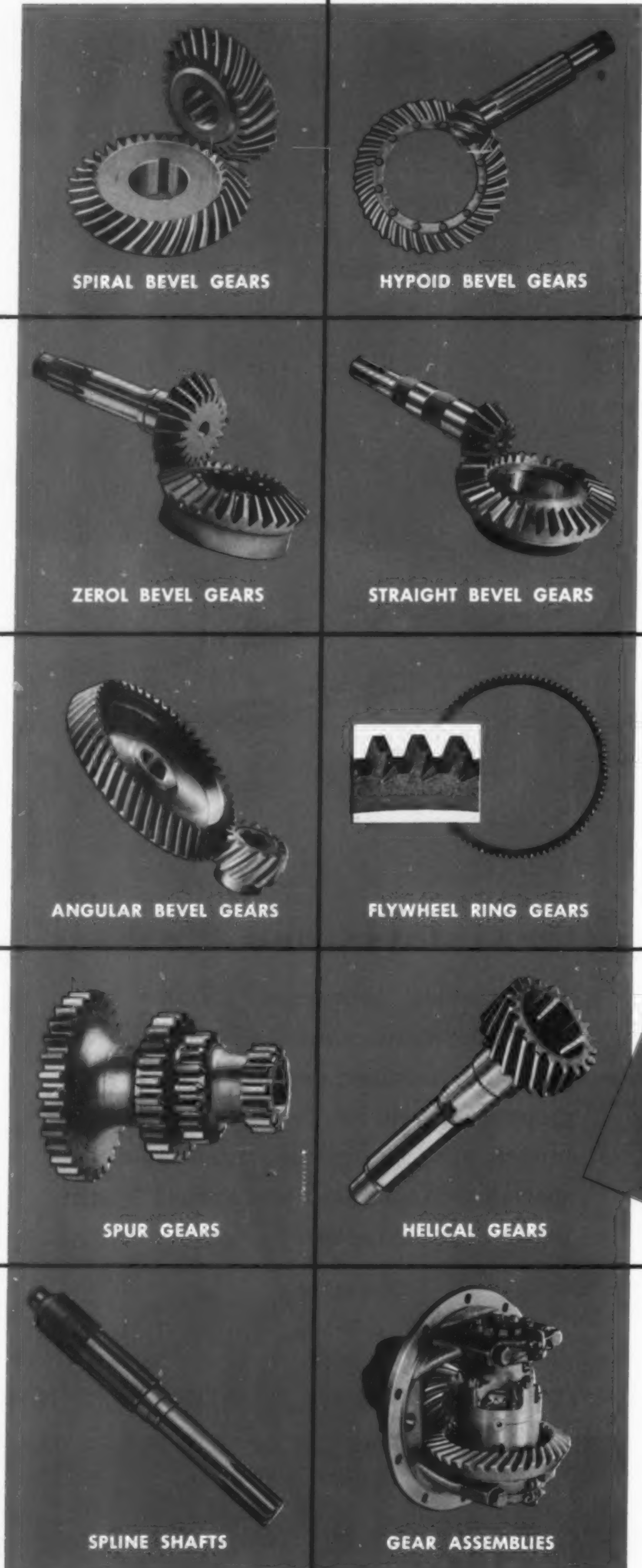
FEDERAL-MOGUL CORPORATION • 11045 Shoemaker, DETROIT 13, MICH.

FEDERAL Mogul

FEDERAL-MOGUL

SINCE 1899

Also sleeve bearings in many designs and sizes; cast bronze bushings; bimetal rolled bushings; rolled split bushings; spacer tubes and bronze parts.



Through 40 years of gear making, these are the 10 gear types that have emerged as our specialties.

If one (or more) of these types is included in your product, it may pay you to review the facts about Double Diamond Gears contained in this book.

We will be happy to send you a copy. Why not write for one today?

DOUBLE DIAMOND
TRADE MARK
GEARS

FOR AUTOMOTIVE, FARM EQUIPMENT
& GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914

RICHMOND, INDIANA

Further Information?

If you would like further information on any of the **ADVERTISEMENTS** in this issue, circle the page numbers of these items on one of the cards below. Then fill in your name and address and mail to us. Your requests will be forwarded to the companies concerned, the answers coming direct to you. When more than one advertisement appears on a page, the following code will be used for identification: T—Top, B—Bottom, L—Left, R—Right (IFC—Inside Front Cover. IBC—Inside Back Cover. OBC—Outside Back Cover)

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- For further information on New Parts and Equipment, Engineering Department Equipment, and Helpful Literature, use HELPFUL LITERATURE REQUEST CARDS—p. 241

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4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN

Penton Building

Cleveland 13, Ohio

FIRST CLASS
PERMIT No. 36
(Sec. 34.9 P.L.&R.)
Cleveland, Ohio

DECEMBER 1954

IFC	51	91	130-1	262	302	337	TL377
1	52	92-93	132	263	303	338	BL377
2	53	94	133	264	304	339	R377
5	54-55	95	134	265	305	340	TL378
6	56	96	135	266	306	342	TR378
8	57	97	136	267	307	343	BL378
9	58	98	137	268-9	308	344	BR378
11	59	99	138	270	309	345	TL379
13	60	100	139	271	310-1	346	BL379
14	61	101	140	272	312	347	R379
17	62-63	102	141	273	313	348	TL380
19	64	103	142	274	314	349	TR380
20	65	104-5	143	275	315	356	BL380
22-23	66	106	144	276	T316	357	BR380
24	67	107	229	277	B316	358	TL381
25	68	108	231	278	317	359	BL381
26	69	109	233	279	318	360	R381
27	70	110	235	280-1	T319	361	TL382
28	71	111	237	282	B319	362	TR382
29	72	112	239	283	320-1	363	BL382
30-31	73	113	240	284	T322	364	BR382
32	74	114	243	285	B322	365	TL383
33	75	115	245	286-7	323	366	BL383
34	76	116	247	288	324	367	R383
37	77	117	249	289	325	368	TR385
38	78-79	118-19	250	290	326	371	BR385
39	80-81	120	251	291	327	373	386
40	82	121	252	292	328	374	387
41	83	122	253	293	329	T375	388
42-43	84	123	254	294	330	BL375	389
44	85	124	255	295	331	BR375	390
45	86	125	256-7	296	332	TL376	391
46	87	126	258	297	333	TR376	392
47	88	127	259	298	334	BL376	IBC
48	89	128	260	299	335	BR376	OBC
49	90	129	261	300-1	336		

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TITLE ______________________

COMPANY ______________________

ADDRESS ______________________

CITY & STATE ______________________

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FIRST CLASS
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8	57	97	136	267	307	343	BL378
9	58	98	137	268-9	308	344	BR378
11	59	99	138	270	309	345	TL379
13	60	100	139	271	310-1	346	BL379
14	61	101	140	272	312	347	R379
17	62-63	102	141	273	313	348	TL380
19	64	103	142	274	314	349	TR380
20	65	104-5	143	275	315	356	BL380
22-23	66	106	144	276	T316	357	BR380
24	67	107	229	277	B316	358	TL381
25	68	108	231	278	317	359	BL381
26	69	109	233	279	318	360	R381
27	70	110	235	280-1	T319	361	TL382
28	71	111	237	282	B319	362	TR382
29	72	112	239	283	320-1	363	BL382
30-31	73	113	240	284	T322	364	BR382
32	74	114	243	285	B322	365	TL383
33	75	115	245	286-7	323	366	BL383
34	76	116	247	288	324	367	R383
37	77	117	249	289	325	368	TR385
38	78-79	118-19	250	290	326	371	BR385
39	80-81	120	251	291	327	373	386
40	82	121	252	292	328	374	387
41	83	122	253	293	329	T375	388
42-43	84	123	254	294	330	BL375	389
44	85	124	255	295	331	BR375	390
45	86	125	256-7	296	332	TL376	391
46	87	126	258	297	333	TR376	392
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48	89	128	260	299	335	BR376	OBC
49	90	129	261	300-1	336		

PLEASE SEND further information on the advertisements appearing on the pages which are circled above.

NAME

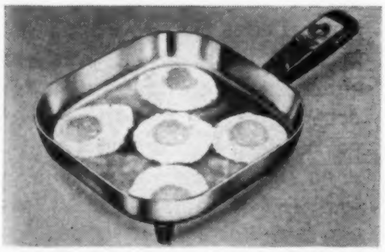
TITLE

COMPANY

ADDRESS

CITY & STATE

3 DIFFERENT PLASTICS...
3 DISTINCT MOLDING PROBLEMS...*tell the inside story of Sunbeam Controlled Heat*



The SUNBEAM Fry Pan: an outstanding example of product beauty and efficiency.

How many years of molding experience . . . what special equipment and engineering skills did it take to work this problem out? SUNBEAM knew . . . and promptly picked Chicago Molded.

The unique phenolic handle of SUNBEAM's Fry Pan contains the electrical controls, is insulated against heat and is designed to keep the electrical connections dry even when the pan is dunked in the dishpan. (Note how the stainless steel tubes are molded right into the handle.) Another excellent example of plastic molding around metal is the nylon head on the cam control. And last, but not least, the escutcheon plate, complete with dial numbers, is injection molded of flame-resistant cellulose acetate.

The three molded plastic components in this SUNBEAM Fry Pan show how Chicago Molded's unequaled experience can be combined with your product design to produce a real sales headliner. Our engineers are available on short notice and without obligation. Why not call them in today? Or, as a starter, send for descriptive literature.

CHICAGO MOLDED
PRODUCTS CORPORATION
1028 North Kolmar Avenue
Chicago 51, Illinois
CUSTOM MOLDERS OF ALL
Plastics
Member, Committee on Large Plastics Moldings, SPI

KENTANIUM*

. . . from powders, a family of high temperature strength, thermal shock resistant, titanium carbide base compositions—for a wide variety of applications at continuous operating temperatures up to

2200°F

—for limited applications up to

4000°F

Many grades of this lightweight, exceptionally pure titanium carbide have been developed for various requirements where conditions of intermittent or continuous high temperatures in oxidizing atmospheres are combined with abrasion and compressive or tensile loads.

These Kentanium grades can be extruded and molded into many forms in the powdered state. More intricate forms are machined from pressed slugs. Precise tolerances are obtained by grinding after the forms have been sintered.

A few of the more important applications and potential uses include: bearings and parts subject to high temperatures in contact with liquid metals, nozzle vanes, blades and wheels for gas turbines and jet engines, rod mill guide inserts.

Additional information is contained in our new bulletin entitled: "Kentanium." Write for it. Then contact Kennametal engineers for cooperation on the application of Kentanium to your specific problem. Our sales offices are located in principal cities. KENNAMETAL INC., Latrobe, Pa.

*Registered trademark

INDUSTRY AND
KENNAMETAL
. . . Partners in Progress

News Roundup

(*Continued from Page 32*)

10 to 1000 pounds and make 1570, M-252 and other newly developed alloys more readily available.

"Kraft suggested to the boss that we needed more office space."

Many Uses For New Sprayed Ceramic

Ceramic coatings that can be sprayed on a great variety of materials have recently been developed by Armour Research Foundation. Called the "solution ceramic" process, the method produces an adherent, nonbrittle and inorganic coating. Solution ceramics contain no bonding agent and can be applied to almost any clean, solid surface at temperatures between 400 and 700 F.

Many different solution ceramics exist. Those most intensively studied so far have been the refractory metal oxides such as zirconia, chromia, titania, ceria and magnesia. Armour reports that certain phosphates, silicates, fluosilicates, oxyhalides and even metals can be deposited in this way. Also, two or more metals may be codeposited or applied in separate layers by the process.

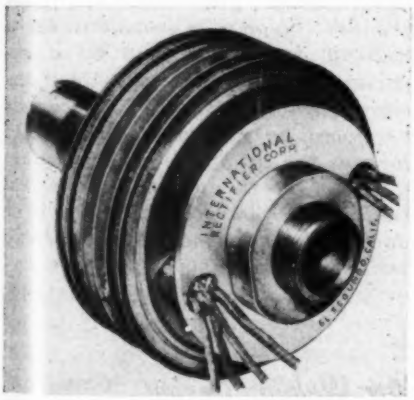
All of the coatings have been found low in density, and this characteristic makes them good thermal insulators as well as nonbrittle. They are relatively soft compared to other ceramic materials.

A thin sheet of metal coated with a solution ceramic can be

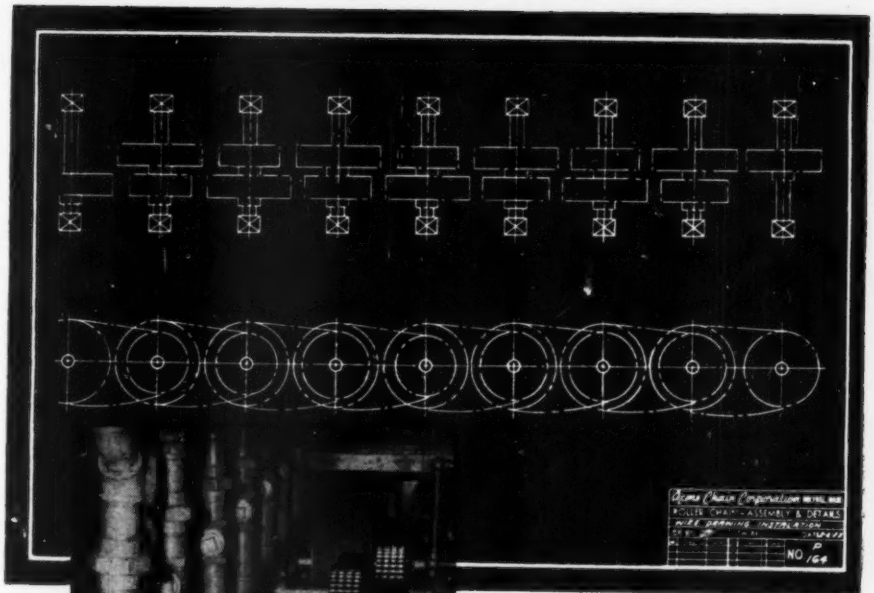
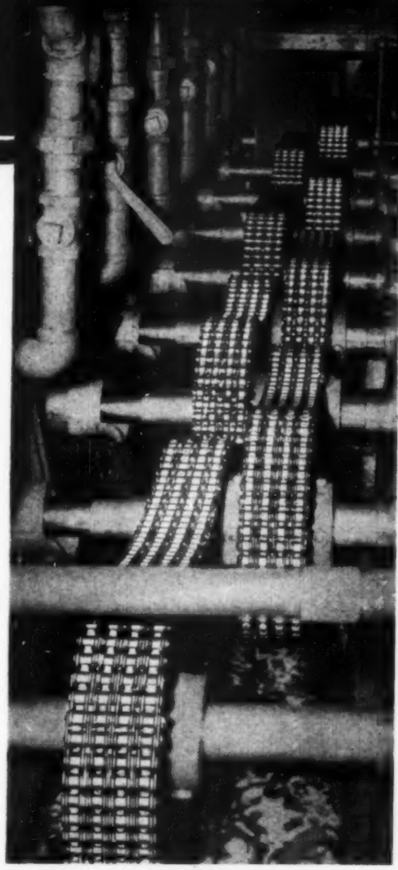
moderately bent or twisted. If the metal is bent sharply, however, the coating powders off at the outer radius. Thus, the coatings are not elastic and will not regain their shape or thickness after deformation. Solution ceramics are said to be protective against molten metal or viscous glass due to their insulative nature. They are protective against corrosion by solids or viscous fluids, against mechanical erosion by gases and against high temperatures.

By controlling the concentration of the solution, the rate at which they may be applied can be controlled. Coatings of infinitesimal thickness have been deposited from very dilute solutions. Armour engineers have found the optimum thickness to be between 0.002 and 0.005-inch. No increase in corrosion protection has been found by increasing thickness beyond this value.

Zirconium oxide, when coated on mild steel, has a dc resistivity of over 1 megohm per cu cm. Solution ceramic platinum exhibits



ROTATING RECTIFIER eliminates commutator and slip rings according to its maker, International Rectifier Corp. Mounting the rectifier on the same shaft as the alternator permits its output to be fed directly to the alternator field windings. Output of the unit pictured here is used to supply the field of a 30-kw diesel generator set

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Long producers of the gears needed in high grade trucks and tractors, Fairfield now brings the same standards for GEAR PERFORMANCE to a wide variety of products: Agricultural Implements ... Power Shovels ... Machine Tools ... Diesel Locomotives ... Road Graders ... Lift Trucks ... Road Rollers ... Pump Drives ... Winches ... Military Vehicles ... and a host of others.

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Fine Gears Made to Order

FAIRFIELD

LAFAYETTE INDIANA

News Roundup

metallic conductivity.

Besides applications of solution ceramics in the prevention of corrosion and resistance to heat, many other new design possibilities are open. For instance, coatings a few millionths of an inch thick have been used to separate magnetic laminates without significantly increasing their packing factor. Opaque, white zirconia coating is suitable as a substitute for ground coats in porcelain enameling or as a base for making lithographic plates.

High-temperature coatings for resistor wire or tape, capacitors, wire-wound conductors and thermocouples are among the uses for solution ceramics in electrical design. Protection of cylinder and piston heads against shock and carbon deposition as well as a gasketing coating for engine assemblies are possible applications in internal combustion engines. Many other commercial applications are expected to be found as additional laboratory tests are completed.

• • • BLIND MAN'S CANE *is the latest thing gone electronic. That familiar tapping is replaced by a whining sound generated by a capacity-type oscillator unit. About the size of a hearing aid, the device was developed by Franklin Institute. As long as the tip of the cane is within 4 inches of the ground, the signal continues. Upon reaching a curb or down-step, the signal stops, warning the user to watch his step.*

Arc Welding Design Contest Is Announced

Eighth annual welded design competition for engineering undergraduates was announced by the James F. Lincoln Arc Welding Foundation. Purpose of the competition is to encourage engineering undergraduates to study the value of welded design in machinery and structures.

A total of 46 awards, the top being $1250, are being offered for papers presenting the welded de-

sign of a machine, machine parts, structures or structural parts. According to the Foundation, competition is for undergraduates only, and each contestant has the opportunity to demonstrate his ability and originality in an engineering design project using arc welding. Since it is primarily a design competition, knowledge of the mechanics of arc welding are not a prerequisite.

Rules and conditions of the contest may be obtained by writing the James F. Lincoln Arc Welding Foundation, Cleveland 17, Ohio.

Whirling Thermometer Takes Turbine's Temperature

Remote indication of gas-turbine blade temperatures is possible using a system recently developed by the National Bureau of Standards. Special high-resistance heat sensing units that withstand large centrifugal forces plus an inductive commutator are the basic elements of the system.

Previous experiments have used resistance - type thermocouples mounted on the blades and electrically connected to the external measuring equipment through slip rings. Rapid wearing of brushes and the necessity of establishing thermocouple cold-junction temperatures presented difficulties. Presence of oil and water vapor made good brush contact difficult at high speeds.

An alternative to brushes and slip rings is the inductive commutator. Essentially, the inductive commutator consists of a number of pairs of input and output coils on a rotating shaft. Stationary pairs of coils are mounted on the turbine frame. Of the stationary pairs, one is designated as the energizing coil; the other of the pair is called the information-receiving coil. The energized coil is excited with current at a low radio frequency. On the rotating turbine blade, the coil pairs are electrically connected together and shunted by a variable-resistance thermocouple.

Rotation of the shafts brings

(*Continued on Page* 44)

Testing Anker-Holth Hydraulic Cylinder to be used on a metal stretch forming press. Cylinder on test is 16″ bore, 69½″ stroke, for 3000 psi operating pressure. Tested at 4500 psi.

Thorough testing of Anker-Holth Cylinders assures you dependable power

● Every Anker-Holth Cylinder... large and small... is tested at 150% of working pressure with the latest completely-filtered testing equipment. Anker-Holth testing facilities include portable units such as the one shown... also stationary equipment for pressures up to 10,000 psi.

This is one of many safeguards in manufacturing to assure you top performance and dependability in Anker-Holth Cylinders. There's a type and size of cylinder to match *your* need. Anker-Holth engineering know-how is available to help solve your power motion problems. Call or write ANKER-HOLTH DIVISION of The Wellman Engineering Co., Dept. A-12, 2723 Conner St., Port Huron, Michigan.

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Revere can supply you, not only with a full line of aluminum sheet products, but with aluminum tube, extruded products, electrical bar, forgings and rolled shapes of the finest quality. Added to these are Revere's renowned copper and brass products which have been staples of American industry for more than 100 years.

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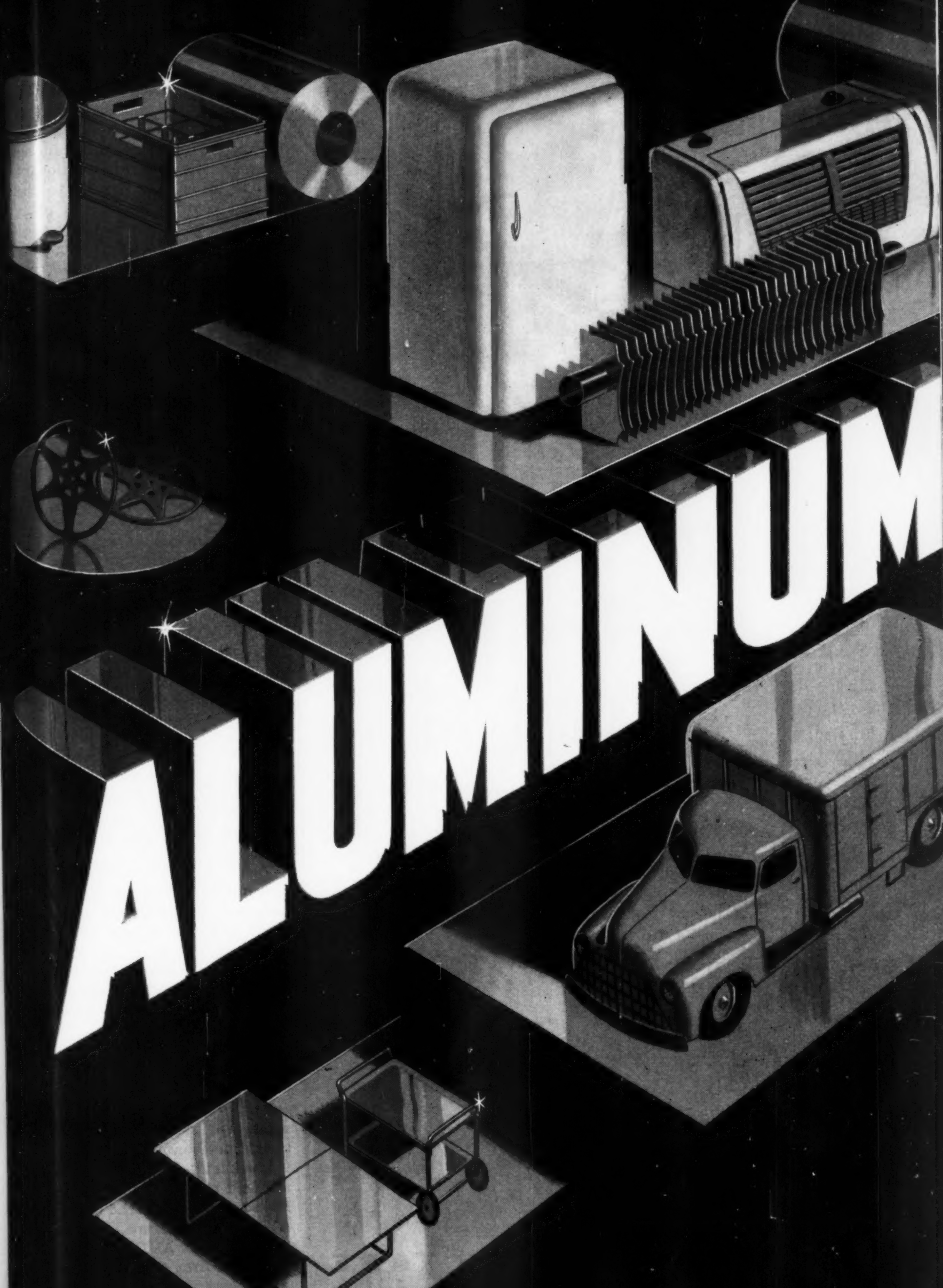
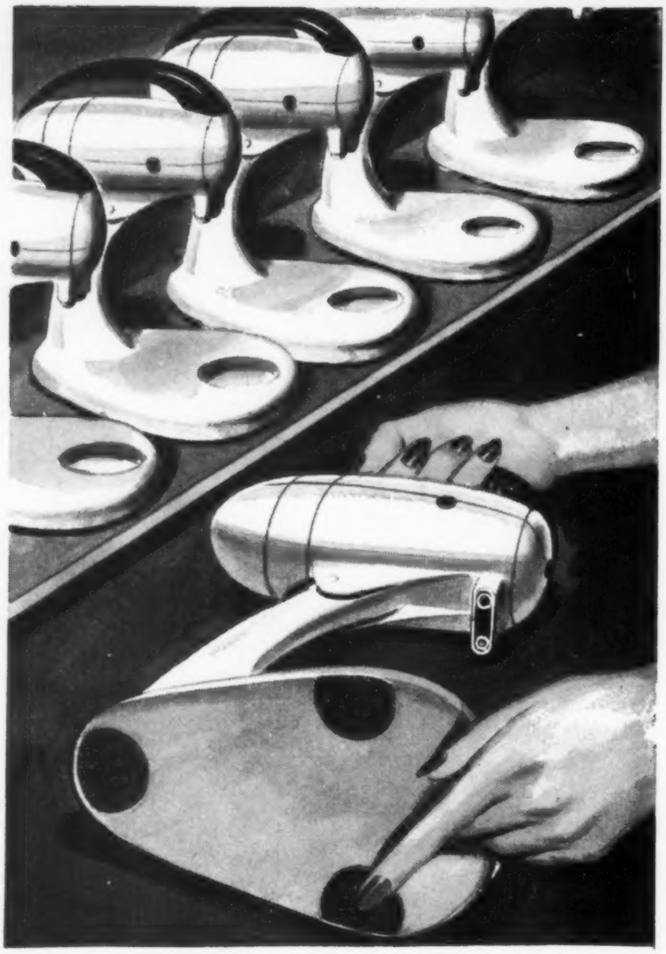
Why not add the Revere A-B-C's to your own alphabet of manufacturing knowledge and experience? Call Revere NOW. Revere Copper and Brass Incorporated, *Founded by Paul Revere in 1801,* Executive Offices: 230 Park Avenue, New York 17, N. Y.


ALUMINUM



skidproof

Pads of Armstrong DK-153 Tape on the bottom of your appliance give it a sure, skidproof, marproof footing. And this resilient cork-and-rubber tape is easy to use. It's backed with a tacky adhesive that sticks to almost any clean, dry surface.

You can get DK-153 material in tapes, rolls, sheets, or die-cut shapes in varied widths and thicknesses. For samples, write on your company letterhead to Armstrong Cork Company, Industrial Division, 7312 Dean Street, Lancaster, Penna. Available for export.

Armstrong DK-153 TAPE

News Roundup

(*Continued from Page* 41)

the rotating and stationary pairs in and out of inductive coupling with each other. At one point during rotation, the energized stationary coil is inductively coupled to one of the rotating coils; the other rotating coil is inductively coupled to the information-receiving coil. The amount of energy transferred between the pair of rotating coils is governed by the resistance of the thermocouple which varies with temperature. Energy is transferred by electromagnetic coupling from the second of the rotating coils to the information-receiving coil. Magnitude of output is independent of speed of rotation.

Since each channel or set of coils is sampled periodically, information is sequential. One of the channels may be used for calibration by substituting a fixed resistance for the thermal element. Synchronizing to allow selection of any one channel for observation is accomplished by electronic circuits which include a pulse generator and amplifier.

High centrifugal forces up to 100,000g made conventional resistance-type thermometers useless. Proper design of the coils, embedding the element in a special cement, and judicious placement in the blade, minimize effects of these severe operating conditions.

Tests on turbines under actual operating conditions indicate temperature measurements may be made with the system to an accuracy of ± 25 F at 1400 F. Calibration of the system has been by comparison with a thermocouple system under identical operating conditions.

Potter and Brumfield Mfg. Co., makers of electrical relays, fractional-horsepower motors and electromechanical assemblies will be acquired by American Machine and Foundry Co. Morehead Patterson, AMF board chairman and president said that AMF expects to acquire the firm as a wholly-owned subsidiary.

News Roundup

Swift Squeezer Sorts Soft Springs

Testing and classification of coil springs for autos is accomplished with a new automatic spring tester. No operator is required and classification is reported to be at the rate of 700 springs per hour according to Hautau Engineering Co., builders of the machine.

Springs are sorted into four classifications: Soft-good, hard-good, soft-no good and hard-no good. Matched sets of auto springs can be assembled, resulting in increased passenger riding comfort.

Springs are compressed by a mechanical ram drven by a standard Cone-Drive speed reducer. Two compression operations check the spring for different characteristics. One compresses the spring to its solid height. The other operation compresses the spring for load calibration and classification.

As the spring comes into the machine, a feed arm pushes it into an index barrel. After the first test compression, the index barrel moves the spring into position for the second test. At the completion of the second test, the spring is dropped onto the proper section of a conveyor. Air valves actuated by electronic relays open exit doors depending upon the classification of the spring.

A 10-hp motor drives a double-enveloping Cone-Drive speed re-

NOW... Another Chrysler First!

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for applications requiring extreme ruggedness, low wear, and unusual ductility.

If you've passed up using metal powder finished machine parts because your applications require units of greater strength and ductility than they normally provide, then you will want to investigate STEEL OILITE.

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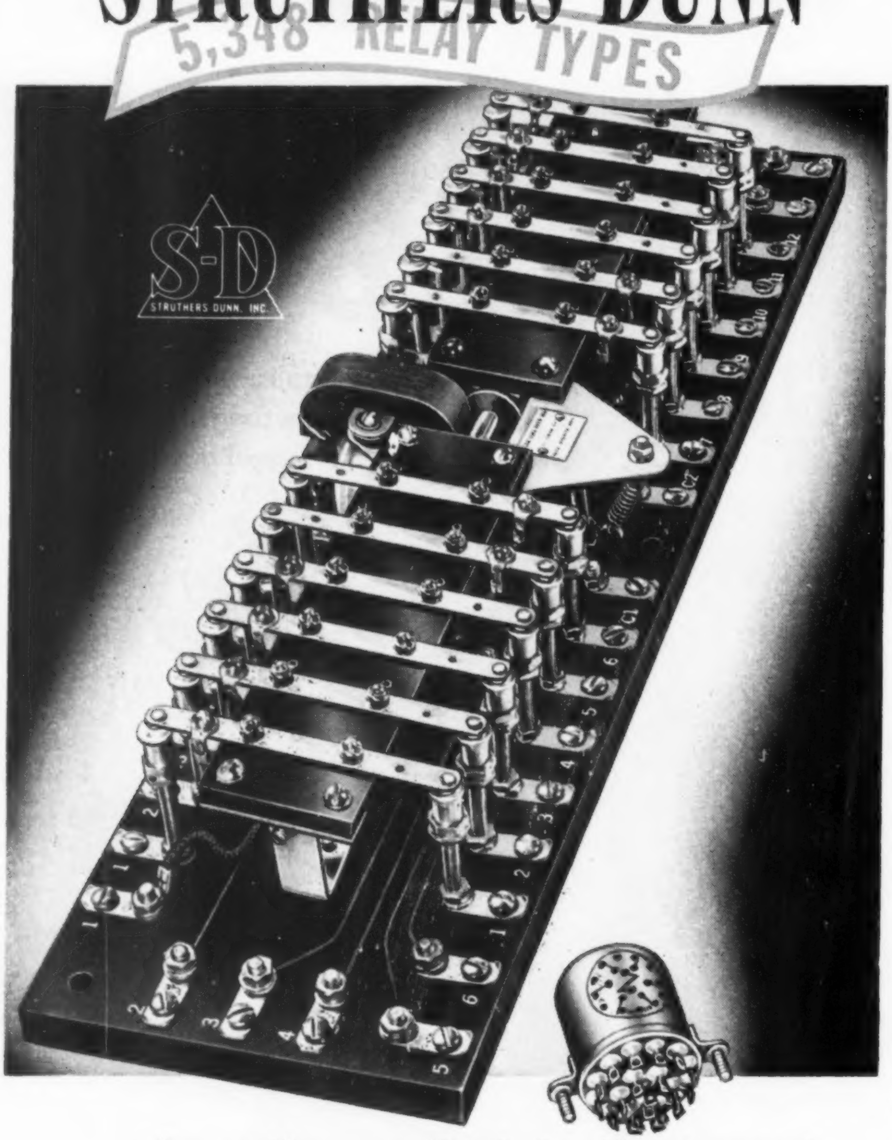

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. . . and everything in between!

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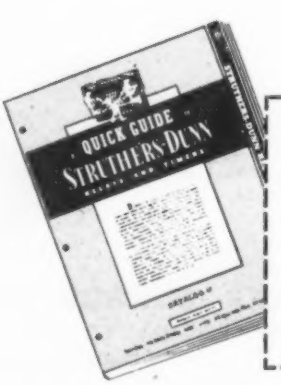

QUICK GUIDE . . . to the most popular of the S-D 5,348 relay types.

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Without obligation send the 20-page "Quick Guide" to S-D relays and timers.

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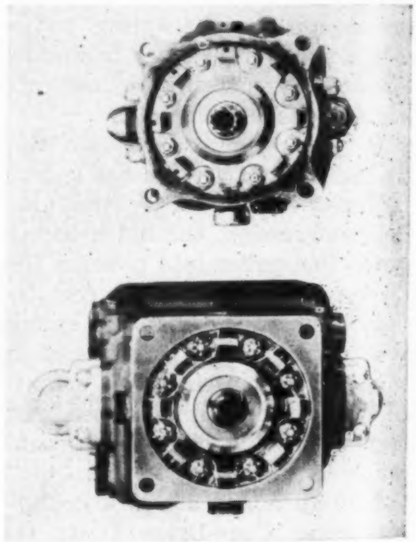
ducer that moves the fork-type ram. Slightly more than 2000 lb is required to compress these particular springs to their solid height.

Steel Replaces Aluminum For Lighter Pump Design

An alloy steel casting replaces aluminum in a redesigned aircraft pump to save weight. High strength of the steel casting along with its extremely thin walls results in a new part weighing less than the aluminum part.

This new pump, designed and built by Vickers Inc., is a piston type utilizing a yoke arrangement



Comparison of the new pump, above, with the comparable pump of previous design, below. Reduction in size of the new pump was achieved by extensive redesign

to vary pump displacement. The previous aluminum yoke was a U-shaped member supported in the housing between two pintles that passed through its arms. It contained internal passages that carried oil from the point at which it entered the pump to the valve plate and cylinder block. Then it returned the oil under pressure to the outlet port.

Redesigning the yoke with integral pintles resulted in a lighter casting as well as providing smoother passages for fluid flow.

Magnesium-zirconium alloy used for the housing also contributes to the lightness of the pump. This material has high strength and produces castings of great density.

Inlet and outlet connections were redesigned to save weight. Previously all steel, the fluid connections are now aluminum with stainless steel inserts. Steel inserts were required because of military specifications dictating steel construction for all threaded connections.

• • • FISH-TASTING DOUGHNUTS *will be a thing of the past when your favorite Greasy Spoon installs new chemically inert hoses on its deep fryers. Used to recirculate and filter hot fat, the Fluoroflex-T hoses were originally developed by Resistoflex Corp. to permit satisfactory handling of synthetic fuels and lubricants in jet aircraft.*

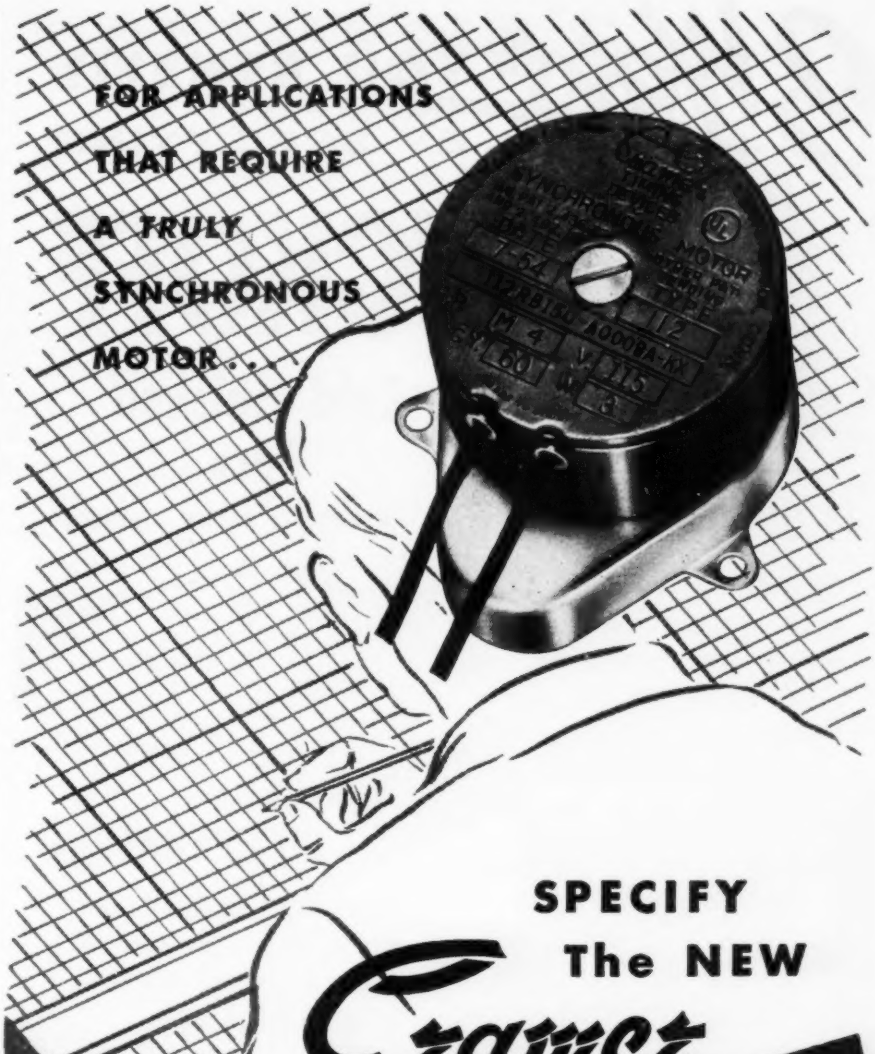
Bearing Life Increased With Sulphur

A new process known as sulphurization or sulphur cementation of steel was reported recently by the U. S. Department of Commerce. Developed in France, the process consists of immersing steel or cast iron parts in a bath of suitable composition and temperature.

Results of the process on hard and soft steels, stainless steel and castings indicate that the parts become highly resistant to friction, and wear and tear. It was reported that alloyed castings and stainless steel respond particularly well to this treatment. Sulphurized steel bearings for rolling cylinder shafts were said to last about six times as long as bronze bearings of identical design.

Fog Provides More Design Flexibility

Fog, oil fog that is, can be designed into a machine tool to provide fast operation over a wide range of metal-cutting operations. A C. A. Norgren oil-fog system installed on a Carlton radial drill



SPECIFY
The NEW
Cramer
TYPE 112
SYNCHRONOUS MOTORS

- Extra reserve strength (30 in. oz. torque at 1 r.p.m.)
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The Cramer Type 112 (or KX) Synchronous Motor is designed especially for instrument and control applications which require constant speed and utmost dependability, even under adverse environmental conditions. It runs only at synchronous speed and stops instantly upon removal of power. Available in many output speeds ranging from one revolution per second to one revolution per day.

Write for Bulletin PB-110.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

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was recently reported to have doubled tap life on a production operation. According to the report, four $\frac{3}{8}$-inch taps were used in drilling 600 holes in $1\frac{1}{8}$ inch steel with conventional coolant. After applying the oil-fog system, one tap was still in service after drilling 300 holes of $\frac{1}{2}$-inch diameter in the same $1\frac{1}{8}$ inch thick steel. Speed of the tap was increased from 265 to 365 rpm.

Because of the finely divided character of the spray, it has the ability to penetrate into crevices and tight interfaces of the cutting area and effectively lubricate the critical points. Its rapid heat dissipation causes the mist to decompose almost instantaneously and the excess vanishes like cigarette smoke. There is no need for recirculating coolant thus eliminating much accessory equipment.

Meetings

AND EXPOSITIONS

Dec. 12-15—

American Institute of Chemical Engineers. Annual meeting to be held at Hotel New Yorker, New York, N. Y. Additional information may be obtained from society headquarters, 120 E. 41st St., New York 17, N. Y.

Jan. 10-14—

Society of Automotive Engineers. Annual meeting and engineering display to be held at the Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Mich. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Jan. 21—

Malleable Founders' Society. General meeting to be held at Hotel Cleveland, Cleveland, O. Additional information may be obtained from society headquarters, 1800 Union Commerce Bldg., Cleveland, O.

Jan. 24-27—

Plant Maintenance & Engineering Conference to be held at the International Amphitheatre, Chicago, Ill. Additional information may be obtained from the exposition management, Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 24-28—

Institute of the Aeronautical Sciences. Twenty-third annual meeting to be held at Hotel Astor, New York, N. Y. R. R. Dexter, 2 East 64th St., New York 21, N. Y., is secretary.

Jan. 24-28—

Twelfth International Heating and Ventilating Exposition to be held at the Commercial Museum and Convention Hall in Philadelphia, Pa. E. K. Stevens, 480 Lexington Ave., New York 17, N. Y., in manager.

Jan. 31-Feb. 4—

American Institute of Electrical Engineers. Winter general meeting to be held at Hotel Statler, New York, N. Y. Nelson S. Hibshman, 33 West 39th St., New York 18, N. Y. is secretary.

Feb. 8-10—

Society of the Plastics Industry. Tenth annual reinforced plastics division conference to be held at Hotel Statler, Los Angeles, Calif. Additional information may be obtained from society headquarters, 67 West 44th St., New York 36, N. Y.

Feb. 14-18—

American Institute of Mining & Metallurgical Engineers. Annual meeting to be held at the Conrad Hilton Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 20 N. Wacker Dr., Chicago, Ill.

Mar. 14-15—

Steel Founders' Society. Annual meeting to be held at the Drake Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 920 Midland Bldg., Cleveland, O.

CALIDYNE'S new 12,500 pound force INTEGRATED SHAKER SYSTEM

A POWERFUL INTEGRATED SYSTEM

Calidyne's new 12,500 pound force shaker system is an achievement in magnitude of force-output and over-all system performance, available in no other vibration testing system. With it you can now meet vibration test specifications with loads far heavier than ever before. It also opens new research and product-testing possibilities to commercial manufacturers.

FULL PERFORMANCE OPERATION OVER A WIDE RANGE

Uninterrupted, full rated performance over the 5 to 500 cps range *without* alternator switching or power factor correction results from a new rotary power supply design, which incorporates two identical alternators series-connected with provision for shifting phase between the two outputs. A new ring-type shaker armature suspension assures pure *linear, sinusoidal* motion of the armature system, rather than motion along an arc found in conventional shakers. Useful load is also greater, due to the high force output and light weight armature: 10g with 1000 lb. load, 20g with 375 lb. load.

EXCEPTIONAL STABILITY AND SIMPLIFIED CONTROL

Amplidyne servo controls hold a set frequency of 500 cps to ± 1 cps, and displacement or acceleration level to $\pm 3\%$. The automatic cycling system further provides automatic changeover from constant displacement to constant acceleration at any preselected point, such as required for conformance to MIL-E-5272A. The new power supply design also permits direct connection of alternators to shaker armature. This eliminates control and switch gear, attendant maintenance and inconvenience.

Complete specifications and details on the Model 82 Shaker and Associated System available on request

THE CALIDYNE COMPANY

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MEN OF MACHINES

With the passing of **Earl L. Shaner**, chairman of the Penton Publishing Co., on November 10, MACHINE DESIGN has lost a highly valued friend and counsellor. When MACHINE DESIGN was launched in 1929 he played a major, if behind-the-scenes, role in establishing the editorial concepts and policies of the new publication, in addition to writing many of the editorials and other features in the early years. Since then he has been a firm guide and genial father-confessor to two generations of MACHINE DESIGN editors.

Earl L. Shaner

Born in Olean, N. Y., sixty-four years ago, Mr. Shaner graduated from Purdue University in 1914 with a B.S. in mechanical engineering. After two years with the Pennsylvania Railroad on locomotive maintenance he joined the Penton Publishing Co. as editorial representative of *Iron Trade Review* (later renamed *Steel*) and *Foundry*. Joining the army shortly thereafter, he served as an officer in France in World War I and in the army of occupation in Germany. Returning to the company in 1919, he became successively engineering editor, managing editor, editor and, in 1937, editor-in-chief of *Steel,* the position he held at the time of his death.

A director of the company since 1925, he was president and treasurer from 1937 to 1949 and since then was chairman of the board.

Edwin L. Wiegand Co., Pittsburgh, has appointed **Joseph L. Nelson** design manager of its Specialty Products Div. He will be in charge of product styling and will work closely with the company's new product planning group. A graduate of the University of Illinois, Mr. Nelson was previously manager of product styling at Magic Chef Inc.

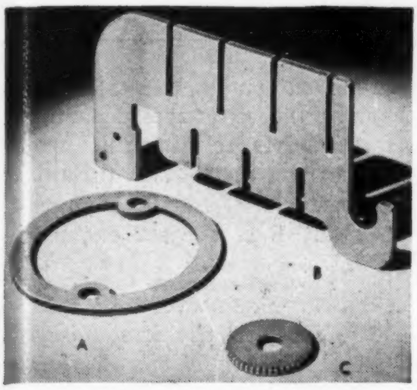
Westinghouse Electric Corp., Pittsburgh, has announced the formation of a new products engineering department to be headed by **Dr. W. H. Brandt.** Dr. Brandt joined the company in 1936 and was formerly manager of special products development.

Richard H. Bergstrand was recently named chief design engineer of Moline Tool Co., Moline, Ill.

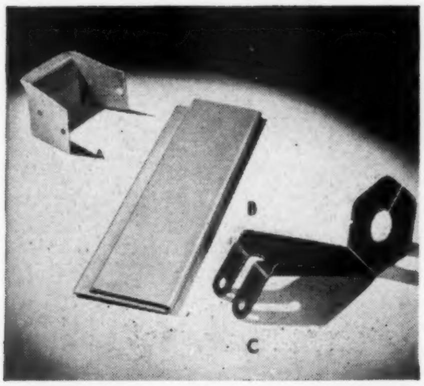
Raymond H. Matthews has been appointed chief engineer of Fenwal Inc., Ashland, Mass. He joined the company in 1951 and for the last year has served as assistant chief engineer.

William W. Kuyper has been appointed manager—manufacturing engineering of the Large Steam Turbine-Generator Dept. of General Electric Co., Schenectady, N.Y. Mr. Kuyper joined the company in 1933 on the engineering test program. He has served most recently as a project engineer for the new turbine development laboratory of the Large Steam Turbine-Generator Dept.

William B. Freeman has joined Temco Aircraft Corp., Dallas, Tex., to head a new division in the engineering department. He will direct activities in the Engineering's Systems Research and Development Div., which includes all the department's technical groups and

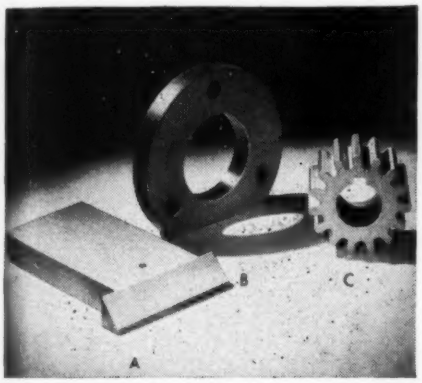


A. Sheet stock, shear strips, punch. B. Sheet stock, shear, punch blank, gang saw notches. C. Sheet stock, shear strips, punch blank, mill notches.

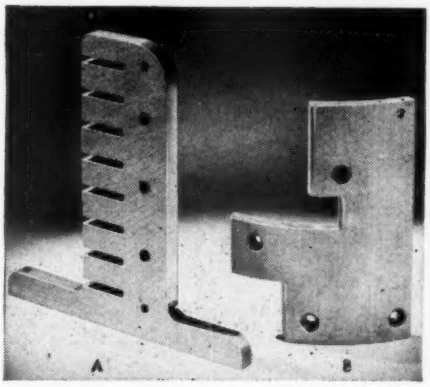


A. Sheet stock, shear strips, punch, form. B. Sheet stock, shear to size, drill, form. C. Sheet stock, shear strips, punch pieces, form in mold twice, rubber stamp twice.

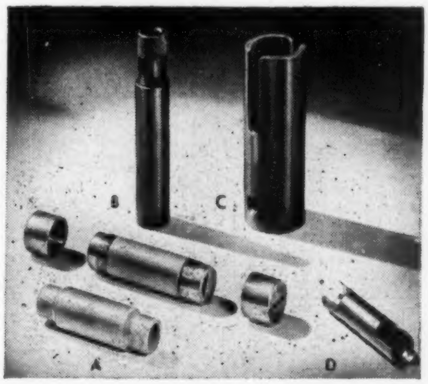
A. Rod (hexagonal), smooth saw, automatic screw machine, turn shoulder thread, champfer and cut off. Remainder are automatic screw machine parts made from Diamond Fibre by C-D-F.



A. Sheet stock, sand, smooth saw to size, smooth saw bevel, smooth saw corner cut out, drill. B. Sheet stock, band saw, turn OD, bore ID, smooth saw side, drill five blind holes with jig. C. Sheet stock, sand, band saw, rough bore ID, hob teeth, finish bore ID, machine keyway.



A. Sheet stock, sand, smooth saw, drill, smooth saw to shape, radius three corners, gang saw nothches. B. Sheet stock, band saw rough blanks, form, smooth saw width, length and shape, radius edges, drill with jig, countersink.



A. Tube, automatic screw machine, turn shoulders, champfer and thread end, thread other. B. Tube (long pieces), smooth saw, tap threads, screw machine, (small pieces) auto. screw machine, thread, knurl, champfer, cut off. C. Tube, smooth saw to length, punch twice, countersink. D. Tube, automatic screw machine, champfer, cut off, punch.

C-D-F fabricates and forms DIAMOND VULCANIZED FIBRE

FAST . . . AT LOW COST . . . DEPENDABLY

Vulcanized Fibre is a wonderful material if you know where to use it and how to buy it. We suggest on many jobs that it's best to do the fabrication and forming in C-D-F's shops. Why? Because C-D-F knows how. Since 1895 the company has put fibre to work in everything from buggy axle bushings to metal clad radio parts. The handling of thousands of set-ups for high speed, low cost production runs gives C-D-F an "experience bank" to draw from. Shop supervisors have a wealth of short cuts, little tricks that result in lower prices for you. They know the material and its peculiarities.

TOUGH, RESILIENT, STRONG

How long has it been since you examined the unique properties and wide range of C-D-F fibre grades? Vulcanized Fibre is arc resistant, mechanically strong, non-corroding, half the weight of aluminum. Repeated moistening and drying in forming insignificantly alters the nature, structure or quality of the fibre.

Since C-D-F has their own paper mill, uniform, quality control is made possible. Special grades are more easily developed. A good example is C-D-F Abrasive Fibre, a medium density fibre with excellent resin and grit adhesion, now widely used for abrasive discs.

A BIG, RELIABLE SOURCE

C-D-F does business with the largest tonnage users of sheet, rod and tube fibre in the world. This means good deliveries, good prices, reliable products for every new customer. You deal with a materials engineer, a C-D-F man who knows how to give you the most value in Diamond Vulcanized Fibre. If you want to improve design, simplify purchasing, speed production, use Diamond Fibre and the facilities of C-D-F. Write for catalog, free test samples, or send us your print for quotation.

CDF *Continental-Diamond Fibre*

CONTINENTAL-DIAMOND FIBRE COMPANY

NEWARK 23, DELAWARE

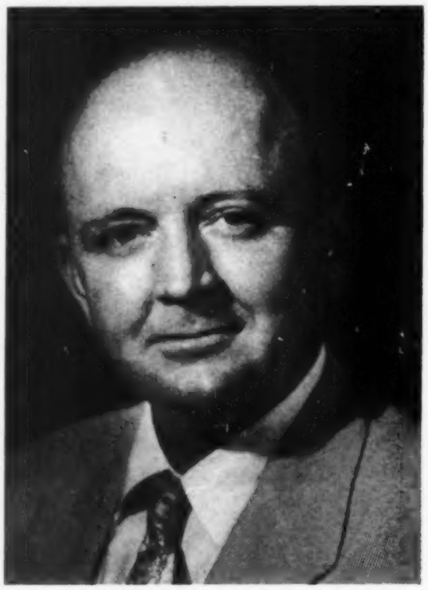
What does "S. B." mean to you?

To some, it means "Sales Boom" . . . a natural corollary to using finer materials. And, to thousands, it means "Small Balls" produced by Universal Ball Company and definitely tied in with Sales Booms.

Sure, we make the larger sizes too, but Universal is getting a universal reputation for these Small Balls of such superb accuracy. Want to roll it around and then get in touch with us?

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.



William B. Freeman

preliminary design functions. Mr. Freeman was formerly associated with Chance Vought Aircraft Corp., where he directed systems engineering on the Regulus guided missile. Earlier, he served for 12 years with the U. S. Marine Corps. He received a baccalaureate degree in aeronautical engineering from the Naval Postgraduate School at Annapolis and also earned a master's degree in aeronautical engineering from Massachusetts Institute of Technology.

Ernest W. Batterson has joined the staff of Sundberg-Ferar, Detroit, as a development engineer. For the last three years Mr. Batterson has been a development engineer for Reo Motors Inc. He was also associated with Mack Trucks Inc. as assistant chief body engineer, with Shakespeare Products Co. as chief engineer, and with the Oldsmobile Div. of General Motors Corp. as a body designer.

William W. Garstang has been appointed chief engineer of the radio division of Allen-Bradley Co., Milwaukee.

The Georgia Div. of Lockheed Aircraft Corp., Marietta, Ga., recently announced the promotion of **R. J. Sorenson** to staff engineer in charge of all electrical and electronic work in the staff engineering department, **J. E. York** to manager of the structural department, **H. O. Davis** to assistant project engineer on the C-130A turbo-prop cargo airplane, and **E. R. Burn** to assistant B-47 project engineer.

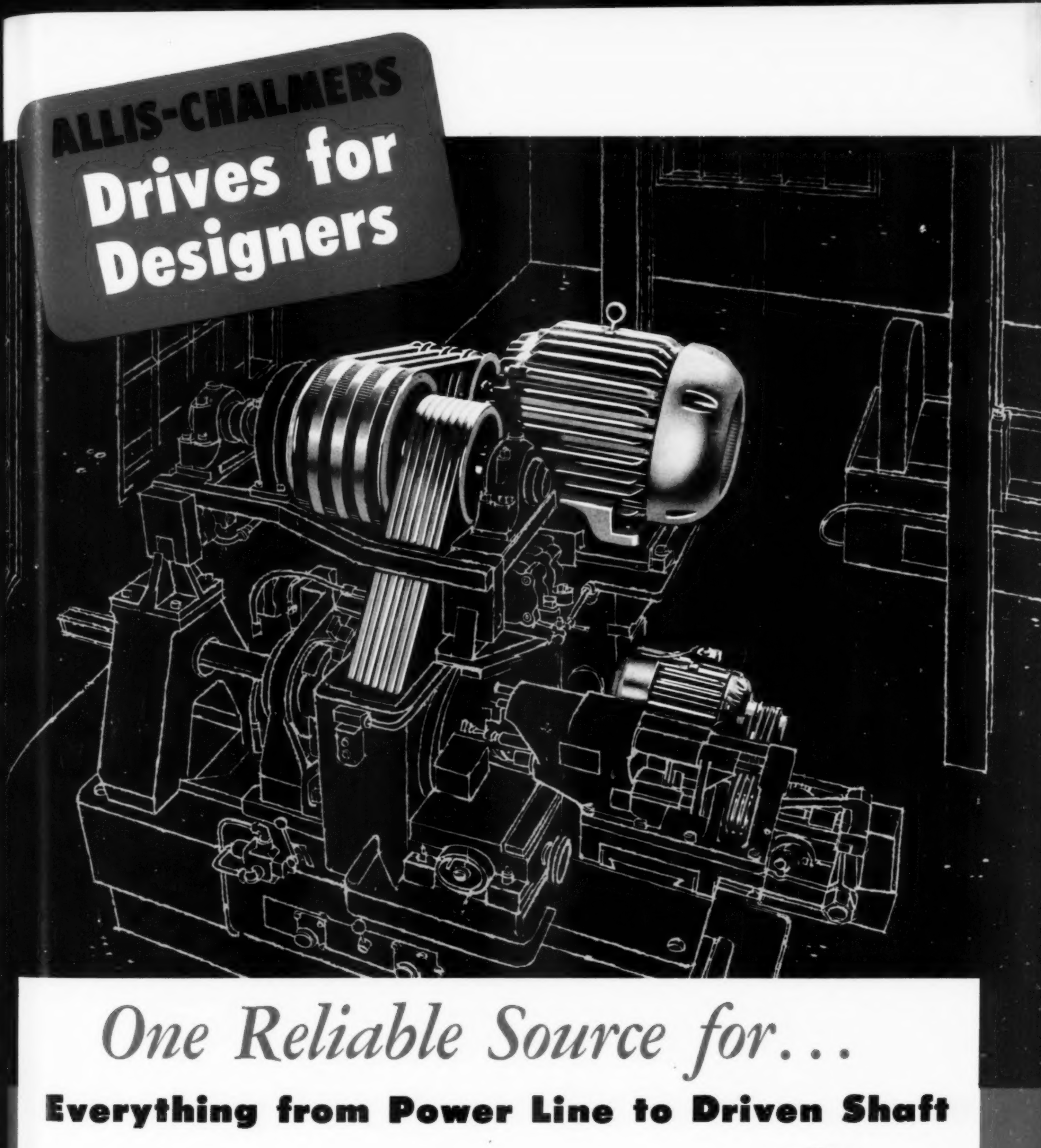
Sutton Engineering Co., Bellefonte, Pa., recently announced the appointment of **Walter F. Larson** as chief engineer of the new Hydraulic Equipment Dept.

James L. Murray has been appointed assistant to the president of the Garrett Corp., Los Angeles. Continuing as engineering representative, Mr. Murray will also report on long-range research and development projects and on new products from the AiResearch Mfg. divisions.

American Bosch Arma Corp., New York, formed by the merger of Arma Corp. with American Bosch Corp., has appointed **Clifton T. Foss** assistant general manager of the Arma Div. He will also continue as vice president of engineering of the division. Mr. Foss received a B.S. in electrical engineering from the University of Wisconsin in 1929. He was with International Communications Laboratories, a division of I. T. & T., before joining Arma in 1933. Here he served as development engineer,

(*Continued on Page* 57)

Clifton T. Foss



ALLIS-CHALMERS
Drives for Designers
One Reliable Source for...
Everything from Power Line to Driven Shaft
Control
Motor
Texrope V-Belt Drive
A-4515
ALLIS-CHALMERS
A-C
ALLIS-CHALMERS
MILWAUKEE 1, WISCONSIN

Simplify YOUR DRIVE DESIGN PROBLEMS

Save Engineering Time and Cost

Select all components for your complete drive . . . motor, control and *Texrope* V-belt drive . . . from one source. Ratings are coordinated to make selection easier. Parts match up properly because they are made to the same engineering and manufacturing standards.

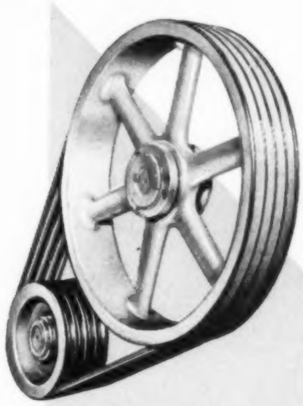
Cut Purchasing Problems

One source means less paperwork . . . fewer orders to issue and follow up . . . coordinated deliveries . . . less expediting.

Reduce Manufacturing Costs

Parts fit together easily at assembly because they are designed and built to be used together . . . to fit a single set of standards. And, of course, you have one responsibility for the performance of the complete drive unit . . . one reliable guarantee of satisfaction.

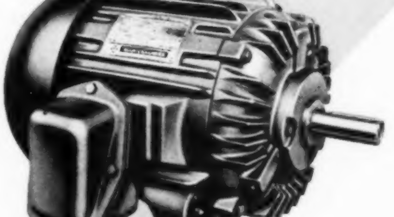
Texrope, Magic-Grip and Vari-Pitch are Allis-Chalmers trademarks.



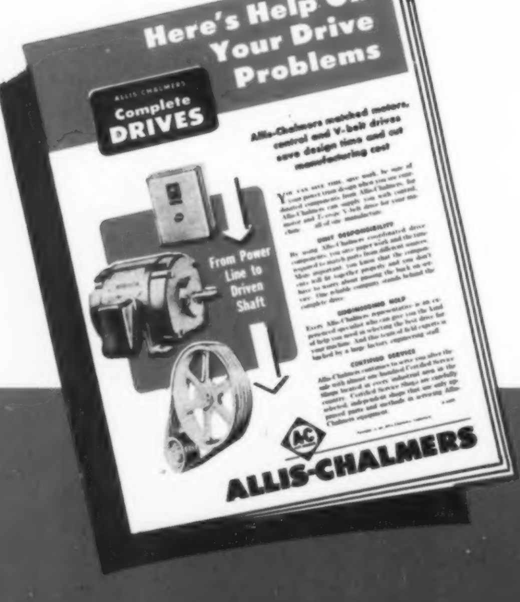
Texrope V-Belt Drive

Everything from Power Line to Driven Shaft

Control

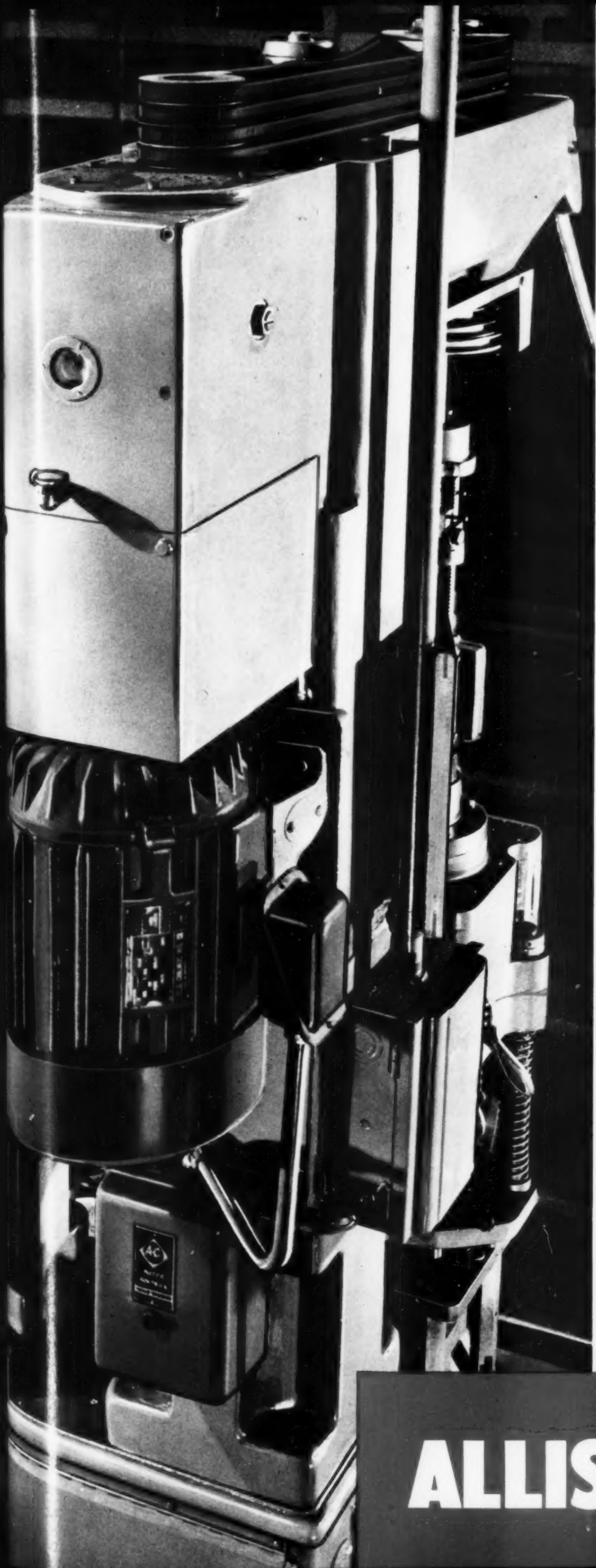


Motor



Get This New Drive Bulletin

This 16-page booklet shows the complete range of Allis-Chalmers power package products plus all-electric package drives and pumps for coolant pumping and air conditioning. For your copy, ask your Allis-Chalmers District Office or write — Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 25B7110.



Texrope Drives

- *Texrope* standard and high capacity V-belts.
- *Magic-Grip* sheaves.
- *Vari-Pitch* variable speed sheaves for stationary or motion control.

More and more designers are finding that the moderate cost of *Vari-Pitch* sheaves is returned many times in increased machine versatility and more precise quality control. With *Vari-Pitch* sheaves, speeds can be accurately adjusted quickly and easily over a wide range.

Motors

- Special and modified standard design motors.
- Drip-proof, TEFC and explosion-proof motors.
- Squirrel-cage, wound-rotor, synchronous and direct current motors from ½ hp up.
- Motors for single, multiple or variable speed operation.

Reduced maintenance of the dirt-shedding TEFC fin-type design is making it very popular for machine tool applications.

Motor Control

- Standard and special starters from size 0 up.
- Variable speed control for wound-rotor and direct current motors.
- Standardized package drives, machine tools and other multiple variable speed motor applications.

A-C
ALLIS-CHALMERS

ALLIS-CHALMERS

SERVICE before you buy

Your Allis-Chalmers field application engineer will be pleased to give you as much engineering help as you want or need. And, because Allis-Chalmers builds many types of power-driven machinery, he's familiar with design and manufacturing problems as well as those concerning specialized motor, drive and control applications.

SERVICE after you buy

Your customers will have no problems getting competent service on the Allis-Chalmers components used in your products. There are nearly 100 Allis-Chalmers Certified Service Shops, located in every industrial area of the country. These shops offer your customers factory-approved parts and service methods. And — if your customers have special Allis-Chalmers equipment, Allis-Chalmers will give the Certified Service Shop all the information necessary to do a top-notch service job.

ALLIS-CHALMERS

MILWAUKEE 1, WISCONSIN

(*Continued from Page* 52)
assistant head, then head of the research and development department, assistant head of the engineering division, chief engineer, and vice president of engineering of Arma Corp.

Frank A. Parker has been appointed director of research and engineering by Detroit Controls Corp., Detroit. He was formerly director of the Detroit Controls Research Div. at Redwood City, Calif.

National Bearing Div. of American Brake Shoe Co., New York, has announced the appointment of **I. Eugene Cox** as vice president in charge of engineering and development. Mr. Cox joined the company in 1935 as a research engineer and, prior to his new appointment, was vice president in charge of engineering.

Karl Schwartzwalder has been named director of research and **Dr. Wilfred A. Bychinsky** has been promoted to assistant chief engineer in charge of spark plug work at the AC Spark Plug Div. of General Motors Corp., Flint, Mich.

John A. Drake has been appointed director of long-range planning and research programs of Marquardt Aircraft Co., Van Nuys, Calif. He was formerly chief engineer in charge of engines and afterburners. **John S. Winter** has been promoted to the position of chief engineer for powerplants to replace Mr. Drake, and **Leigh Dunn** was named chief engineer for test facilities.

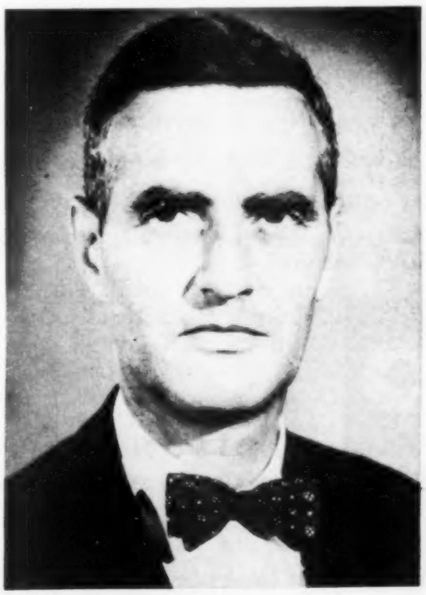
Formerly chief engineer of the Turbine and Gear departments of De Laval Steam Turbine Co., Trenton, N. J., **Harry Engvall** has been promoted to the post of executive engineer. Mr. Engvall graduated from Orebro Technical College in Sweden, came to the United States in 1923 and joined De Laval the following year. In 1943 he was placed in charge of marine turbine design and since that time has served as assistant chief engineer of the Helical Gear Dept., chief engineer of that department, and chief engineer of

Harry Engvall

the Turbine and Gear Depts. He is a member of the American Society of Mechanical Engineers, the American Society of Naval Engineers and the Society of Naval Architects and Marine Engineers.

Succeeding Mr. Engvall as chief engineer of the Turbine and Gear Dept. is former chief research engineer **John S. Haverstick.** Mr. Haverstick joined the company in 1938 and was assistant chief engineer of the Gas Turbine Dept., then acting chief research engineer before being named chief research engineer. He holds an M.S. degree in mechanical engineering from the University of Pennsylvania.

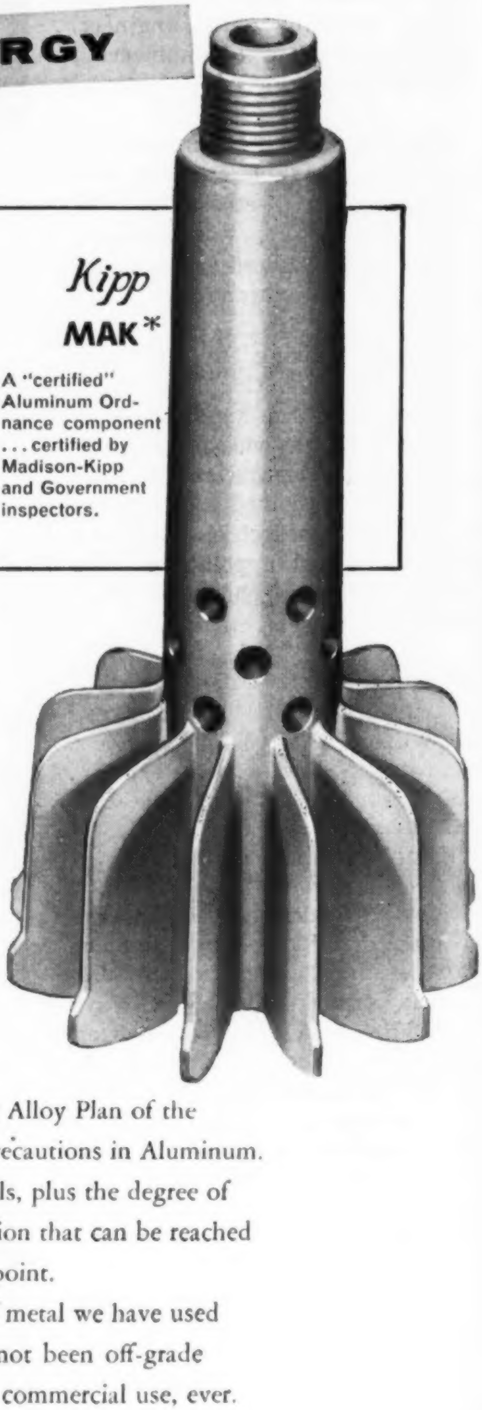
John S. Haverstick



MADISON-KIPP OFFERS

A TIME TESTED FORMULA IN DIE CASTING METALLURGY

Z
Kipp
A "certified" 3.86 lb. Zinc Die Casting . . . certified by the Certified Zinc Alloy Plan and Madison-Kipp.



Kipp
MAK*
A "certified" Aluminum Ordnance component . . . certified by Madison-Kipp and Government inspectors.

We belong to the authoritative Certified Zinc Alloy Plan of the American Die Casting Institute. We take similar precautions in Aluminum. The degree of adherence to these effective certified controls, plus the degree of good housekeeping, equals the degree of perfection that can be reached in die casting metallurgy from an operational standpoint.

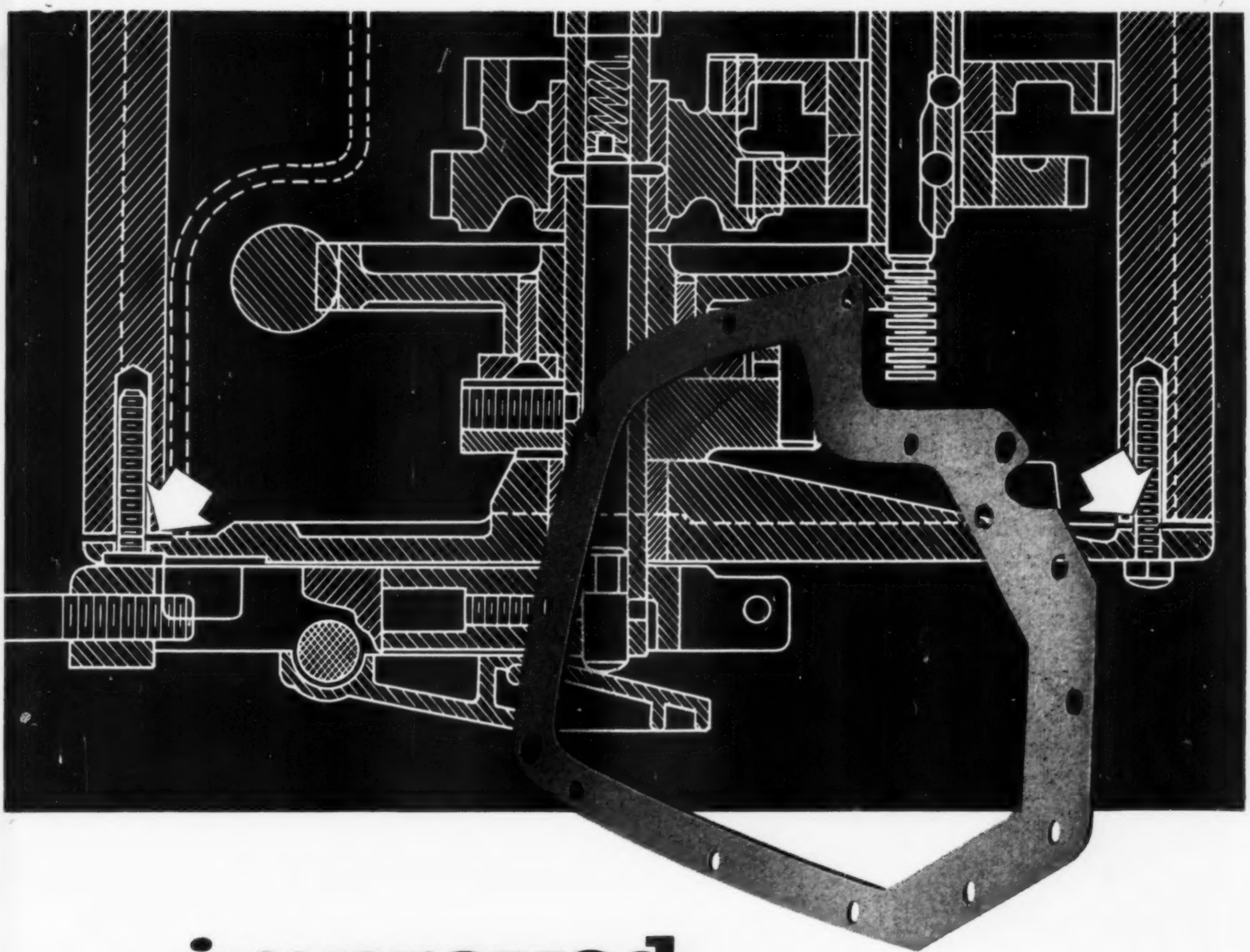
Good housekeeping has kept the mountains of metal we have used to the exact original certified specifications. We have not been off-grade on any casting whether for Ordnance or commercial use, ever.

kipp

*Official designation on Ordnance components.

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U. S. A.

• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools



improved fiber gasket

withstands enamel baking cycle, maintains tight seal

Gasket failures can occur before a product leaves the plant—during assembly and finishing processes. And such failures can be costly.

This was the experience of a manufacturer of electric ironers. Each ironer gear case was put through an enamel baking cycle after it was assembled. The original gasket being used between the aluminum gear case and cover generally sealed well, both before and after being heated. But in an effort to reduce costs, the manufacturer tested other less expensive gasket materials. Each one, however, permitted torque loss and leaked grease during and after the enamel baking process.

Then a new, improved fiber gasket material was tried—Armstrong CS-301 Accopac®. It maintained torque in spite of baking heat. No grease leaks developed. The manufacturer lowered costs and was assured a dependable, long-lasting seal.

Accopac withstands normal manufacturing and service conditions because of the way it's made. Cellulose fiber and cork are blended with a non-extractable latex binder by a patented beater saturation method. The finished material is dimensionally stable, uniform, and highly compressible.

Where can you use Accopac? Use it wherever you need extra dependability in a low-cost gasket material. Although relatively new, Accopac already is widely accepted for sealing pumps, engines, air compressors, aircraft devices, automotive equipment, gear housings, and household appliances.

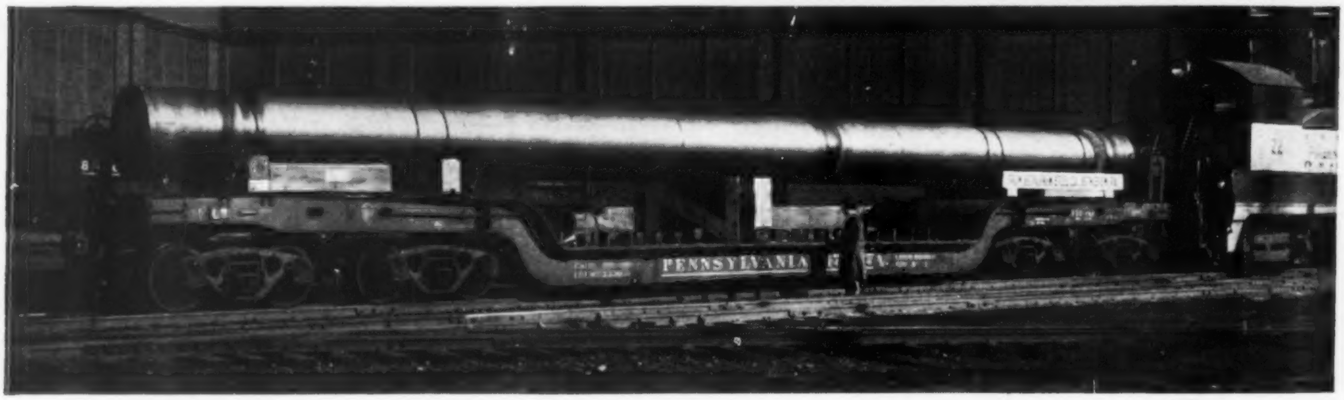
FREE 24-PAGE GASKET MANUAL—Look for "Armstrong's Gasket Materials" in Sweet's product design file . . . or write for your personal copy to Armstrong Cork Company, Industrial Div., 7012 Dean Street, Lancaster, Pennsylvania. **And be sure to specify Armstrong Gasket Materials when you order from your gasket fabricator.**

Armstrong Accopac

BIG ONES

From Forge Shop and Foundry

Some of the biggest forgings and castings made in the world come out of the Bethlehem shops, and many of them are impressive things to see. For example, that massive steel column on the freight car. It is just one inch shy of 70 ft long and weighs 155 tons. For an idea of the size, look at the man standing alongside the railway car. It would take twelve of him, laid end to end, to match the length of the forging.



The big cast sheave wheel isn't exactly a peewee, either. Even though it weighs "only" 30 tons, it's still a mighty big casting. Some intricate work in that piece, and it's typical of the many huge and complex shapes that Bethlehem makes each year.

Down at the other end of the scale, sizewise, are the products of Bethlehem's drop forge shops. Some are so small they can easily be held in the palm of your hand, or balanced on a fingertip. Others take muscle to lift; the 69-pounder shown on this page is a fairly hefty specimen.

Your own needs may fall between the extremes of large and small. But whatever your requirements in forgings or castings, by all means check with Bethlehem. We are equipped to do the job you want . . . whether the pieces are heavy tonnage, or in the medium or lightweight brackets.

Compared to the big press forgings and heavy castings, drop-forged pieces are flyweights. But they're an important item at Bethlehem shops, which have turned out millions of them.

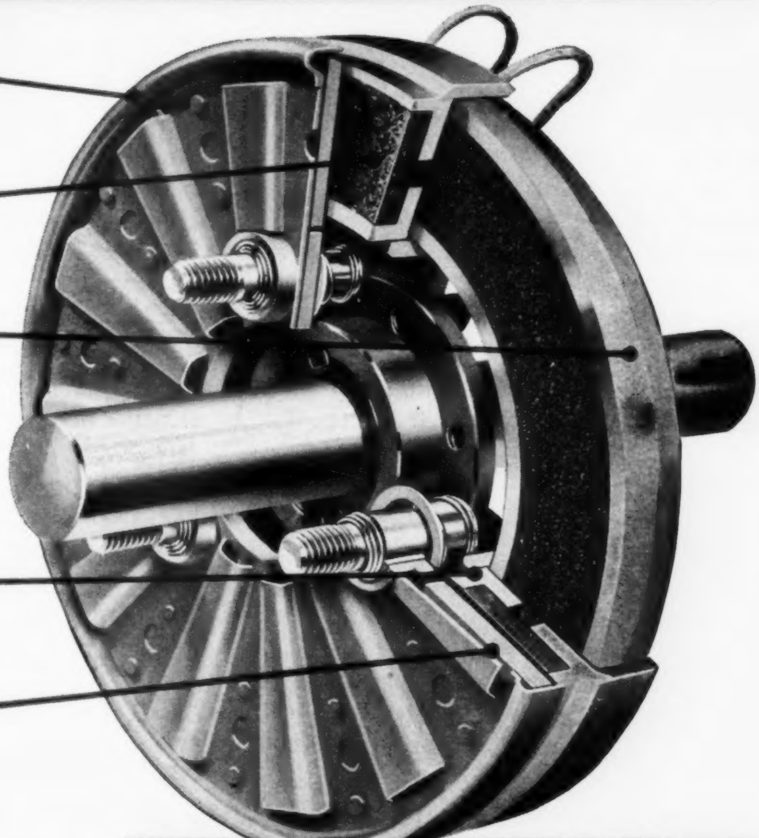
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM FORGINGS and CASTINGS

NEW ... HIGH-TORQUE STATIONARY-FIELD ELECTRIC CLUTCHES FROM WARNER



NEW *companion line* to broaden applications for Warner Electric Clutches. Simplified design.

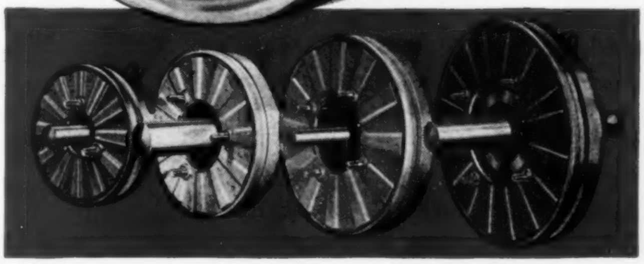
NEW *thicker, tougher friction surfaces* keep clutch operating longer, without service or adjustment.

NEW *design flexibility*—may become part of existing machine drive. Easily adapted for use with standard power transmission equipment. Magnets available for both inside and outside mounting. Faster and easier to install.

NEW *rotor* between armature and magnet may be replaced to extend service life.

NEW *foolproof design*—armature cannot wear into coil section.

Offers simplest, fastest form of "touchbutton" control!



If you are contemplating design changes to make your machines more saleable and reduce costs, here's a new and simple method of controlling high-torque rotary drives automatically or by pushbutton. The new Warner "SF" (stationary-field) Electric Clutches offer instantaneous electro-magnetic engagement and release of torque loads up to 700 ft. lbs. (max. static torque rating). They are easy to install and control by means of conventional light-duty switches, relays, electric eyes, and other automatic controls. Positive, no-slip drive is through armature and rotor. Wear take-up is automatic. Torque build-up is precisely controlled by a rheostat in the power unit. Ideal for accurate indexing, inching and jogging, rapid cycling, synchronized starting and stopping, and numerous other jobs requiring split-second response. Complex mechanical linkages are eliminated. Add outstanding new sales features to your machines this easy, low-cost way. Send coupon below for complete facts.

WARNER

Beat competition with

ELECTRIC BRAKES AND CLUTCHES

WARNER ELECTRIC BRAKE & CLUTCH CO., BELOIT, WISCONSIN

Warner Electric Brake & Clutch Co.
Dept. MD, Beloit, Wisconsin

☐ Please send free catalog describing Stationary-Field Electric Clutches.
☐ Have Warner Representative call.

Firm Name____________________

Individual________________ Title________

Address____________________

City________________ State________

Are You BARRED

from planned assembly savings

BY A THREAD?

No MATTER how carefully you plan to take advantage of the proved speed and simplicity of the self-tapping screw *method*, your planning won't pay off if "softies" and "cripples" turn up among the screws you use.

Screws can be "trouble-bent" in many ways. Like the thread faults listed here, most are invisible, but their effects (job slowdown, parts spoilage, high reclamation expense, hidden weakness) show up clearly in mounting assembly costs and customer complaints.

That's why P-K quality standards have been set so high — to make sure you get Self-tapping Screws that are not only threaded, but headed, pointed, and heat-treated with one purpose in mind, to keep your assembly lines trouble-free.

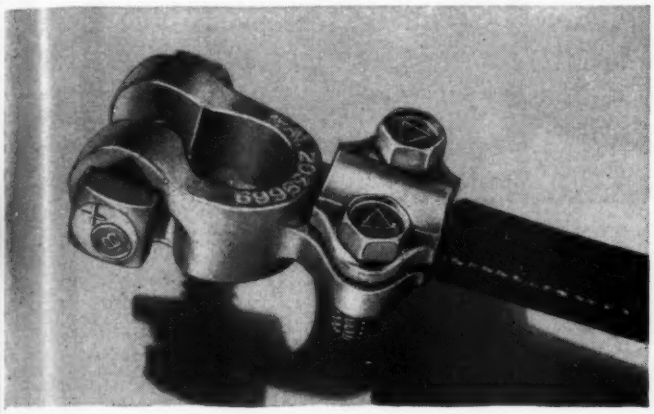
P-K Self-tapping Screws are the leading choice of experienced specialists who plan assembly of America's best known products. Follow their lead . . . for day-in, day-out dependability, specify P-K. For information on any fastening problem, talk to a P-K Assembly Engineer . . . Parker-Kalon Division, General American Transportation Corporation, 200 Varick St., New York 14. Chicago Warehouse, 4331 West Lake St., Chicago 24.

P-K STANDARDS protect you against the thread faults illustrated and many others that will cause assembly trouble and weak fastenings. They don't "get by" P-K inspectors — that's why *all* P-K Self-tapping Screws can be "Guaranteed First Quality."

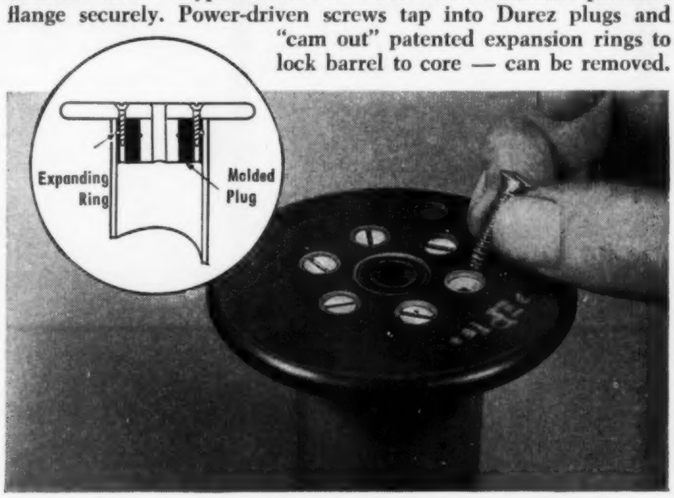
PARKER-KALON

IN STOCK . . . see your nearby P-K Distributor . . .

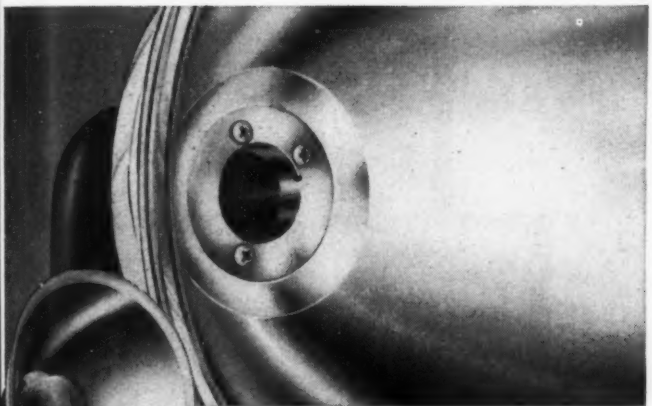
SOLDERLESS BATTERY TERMINAL assembly by Triple-A Co. was reduced from 5 to 2 operations when P-K Hex Head Type F Screws were adopted as clamp fastenings. Screws clear cored holes as they are driven by automatic machines — eliminate drilling, tapping, and awkward screw handling. They provide firm, sure grip on terminal, yet can be removed and replaced if necessary.

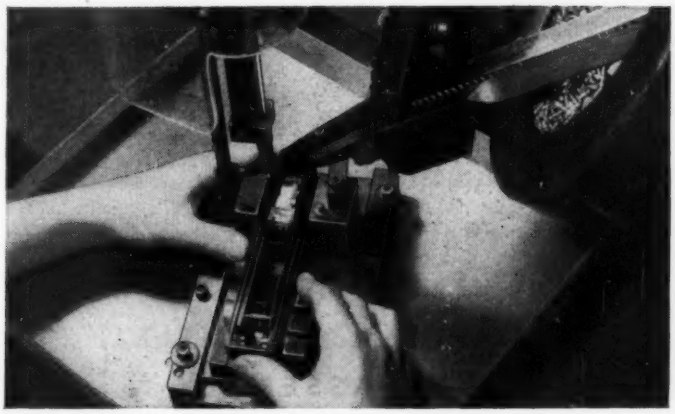


EPI BOBBINS, products of Engineered Plastics, Inc., must withstand extreme end pressure of nylon and other synthetic yarns under tension. Six P-K Type F-Z Screws fasten each laminated phenolic flange securely. Power-driven screws tap into Durez plugs and "cam out" patented expansion rings to lock barrel to core — can be removed.



with P-K quality-planned assembly savings pay off





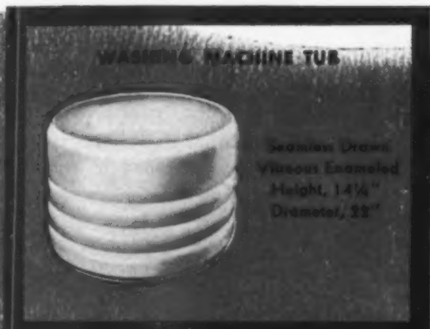
EASTMAN KODAK speeds up assembly of the Kodalite Flashholder by using P-K Self-tapping Screws. Troublesome tapping of small holes in plastic is eliminated. Screws are driven with hopper-fed automatic machines, removing necessity for tedious screw handling and placement. Two P-K Phillips Head Type F Screws fasten a cover mounting bracket to the flashholder case (right) and three more fasten the metalized Tenite II reflector to the case (left). Case is a thermo-setting phenolic. Screws hold firmly under all stresses of normal use, can be removed for attachment of new reflector.

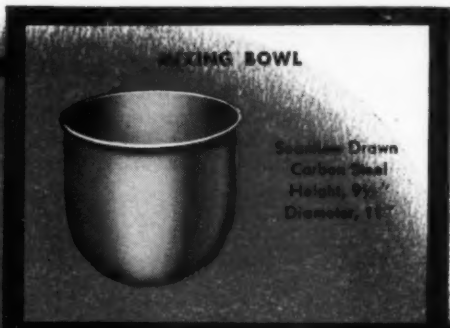
The First

originated by P-K . . . and First Today . . .
the leading choice for fastening economy

SELF-TAPPING SCREWS

ur local Supply and Service Specialist





IT'S OUR BUSINESS

TO MAKE STAMPINGS LIKE THESE

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G.P. & F.

...MEETS YOUR NEEDS FOR LARGE AND MEDIUM SIZED SEAMLESS STAMPINGS *plus* COMPLETE FINISHING AND ASSEMBLY FACILITIES

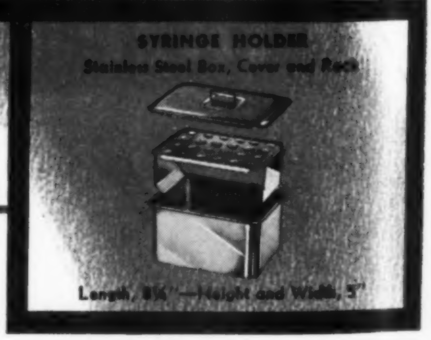
● If you use seamless drawn stampings—whether it's for ammunition boxes or washing machines—G. P. & F. can fill your requirements, *economically.* What's more, G. P. & F. meets the most rigid delivery schedules with parts that pass strictest quality tests!

G. P. & F. specializes in large and medium sized seamless drawn stampings. And we have complete facilities for finishing and assembling ... galvanizing, spray finishing, vitreous enameling, welding. Over 74 years' experience ... 1000 skilled people ... 293 deep draw and stamping presses ... 97 welding machines. And a complete tool and die department. What's more, we can package your products and ship directly to your customers.

So, if you need deep drawn or stamped metal parts for your products, call on G. P. & F. We'll give you complete information, and help solve your production problems.

Write today for copy of booklet—"Science and Skill in Sheet Metals." It illustrates many jobs produced for Geuder, Paeschke & Frey customers ... gives complete data on our facilities.

G.P.&F.
CONTRACT DIVISION

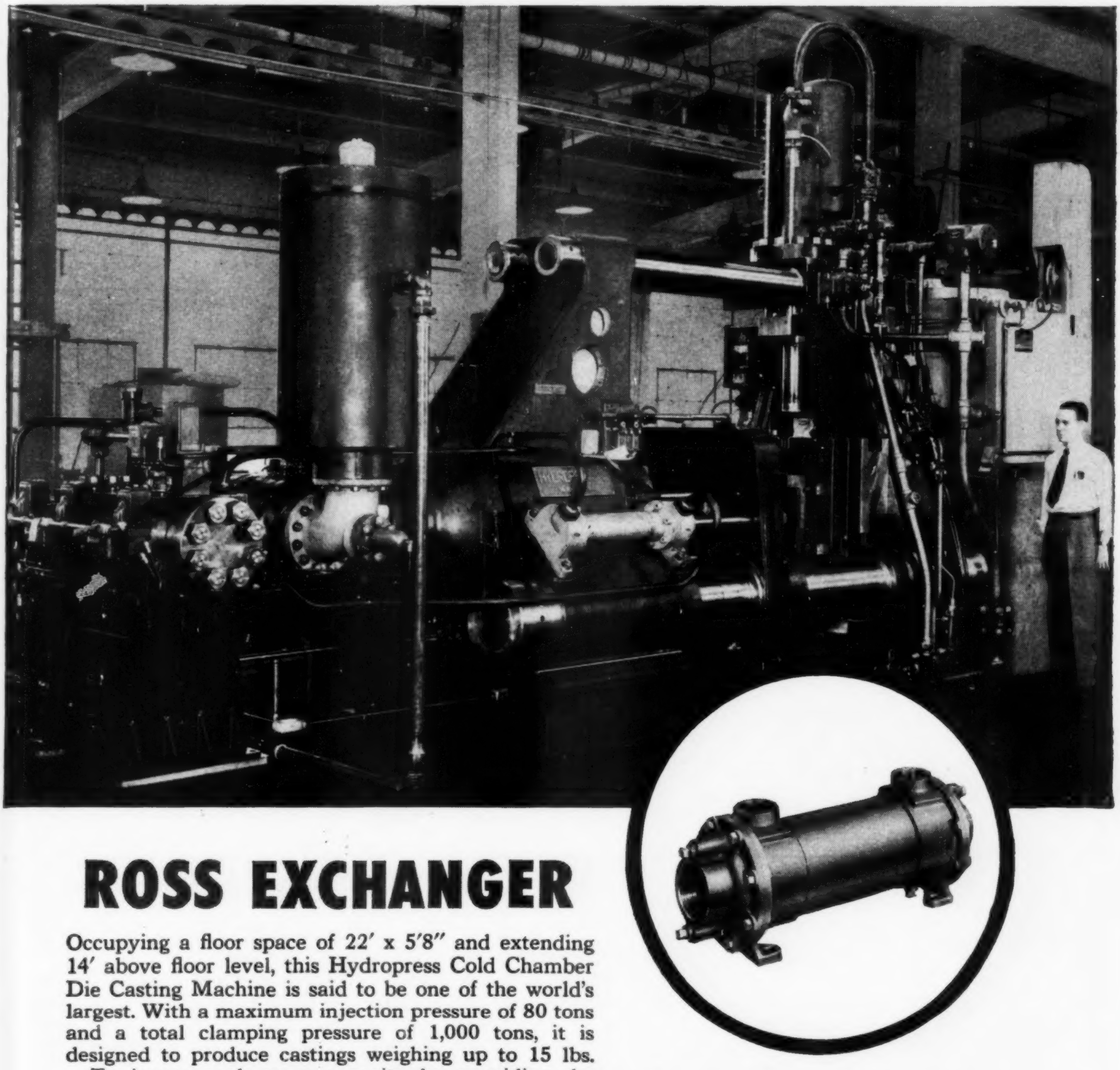


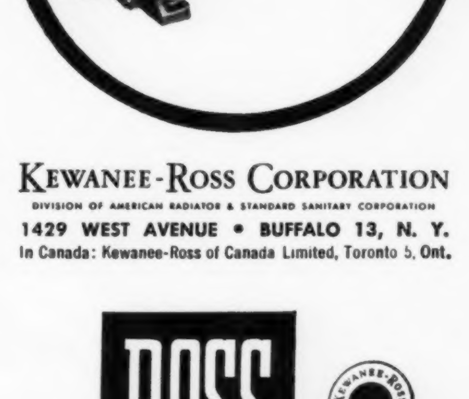
GEUDER, PAESCHKE & FREY CO.

1636 W. St. Paul Avenue, Milwaukee 1, Wisconsin

CONTROLLING OIL TEMPERATURE

while this giant Hydropress produces 15 lb. die castings





ROSS EXCHANGER

Occupying a floor space of 22′ x 5′8″ and extending 14′ above floor level, this Hydropress Cold Chamber Die Casting Machine is said to be one of the world's largest. With a maximum injection pressure of 80 tons and a total clamping pressure of 1,000 tons, it is designed to produce castings weighing up to 15 lbs.

To insure peak press capacity by providing dependable oil cooling, Hydropress, Inc. equipped this machine with a Ross Type BCF Exchanger. *Pump slippage from overheated, thinned oil is most effectively prevented.*

Preferred for numerous types and makes of hydraulic machinery, Ross Exchangers are ruggedly built to withstand punishing hydraulic shock. Tough, ductile seamless copper alloy shells and brass forgings can well absorb the extra load.

Pre-engineered and fully standardized, compact Ross Type BCF Exchangers are stocked in a wide range of sizes to meet most needs . . . *promptly.*

For detailed information, request Bulletin 1.1K5.

KEWANEE-ROSS CORPORATION

DIVISION OF AMERICAN RADIATOR & STANDARD SANITARY CORPORATION

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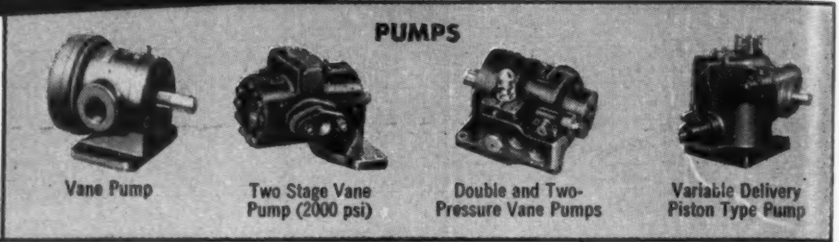
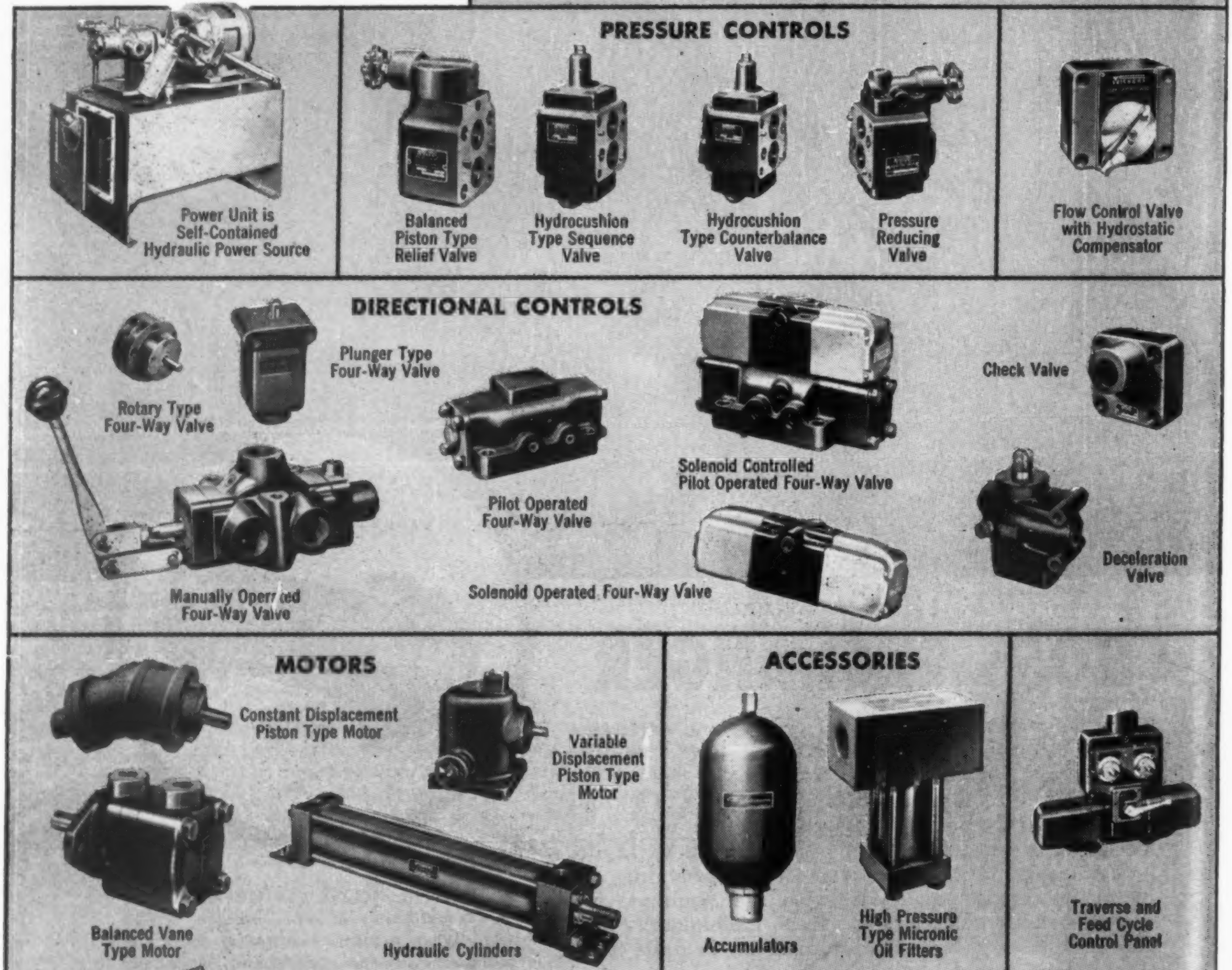
VICKERS® ...the MOST EXTENSIVE LINE of hydraulic units complying with JIC STANDARDS

Shown here are only a few representative standard Vickers units that comply with JIC Standards . . . standards that are directed toward ease of maintenance, safety, longer life and uninterrupted machine production. "Undivided Responsibility" is another important advantage gained by specifying Vickers Units throughout a hydraulic system. For further information ask for new Bulletin 5002.





6865

WRITE for your copy

Vickers Circuitool consists of a handy, transparent plastic guide and a 24-page manual to speed the drawing and to promote symbol (JIC) uniformity of hydraulic circuits.

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

This simple idea saves money in V-Belt Costs

You can prove it in two minutes!

To prove how the CONCAVE SIDES of GATES VULCO ROPES *save money,* just make this simple test—

Bend *any* V-Belt that has *straight sides* (Fig. 1) and—as the belt bends—*feel* the sides *bulge out* (Fig. 1-A). This out-bulge concentrates the wear at the points shown by arrows—and this naturally shortens the life of a *straight-sided* belt!

Now bend a Gates Vulco Rope with CONCAVE SIDES (Fig. 2)

(U. S. PAT. 1813698)

You find that the CONCAVE SIDES *fill out* and become perfectly straight. They thus press *evenly* against the V-pulley. All wear is distributed *uniformly* across the *full width* of the GATES VULCO ROPE—and this means *longer* belt *life* and *lower* belt *cost* for you!

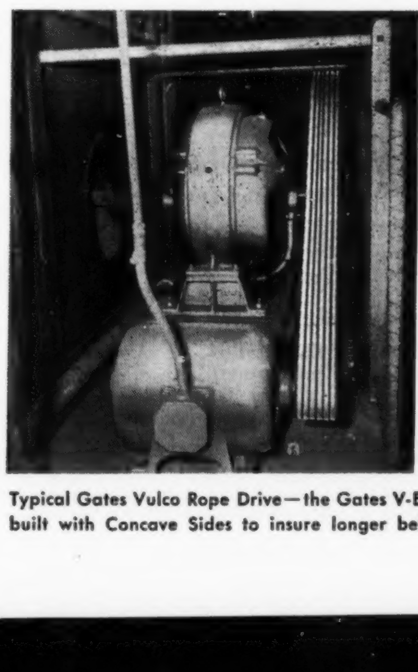
When you buy V-Belts, be sure to get the V-Belt with the CONCAVE SIDES—the GATES VULCO ROPE!

Gates (REG. U. S. PAT. OFF.)

VULCO ROPE DRIVES

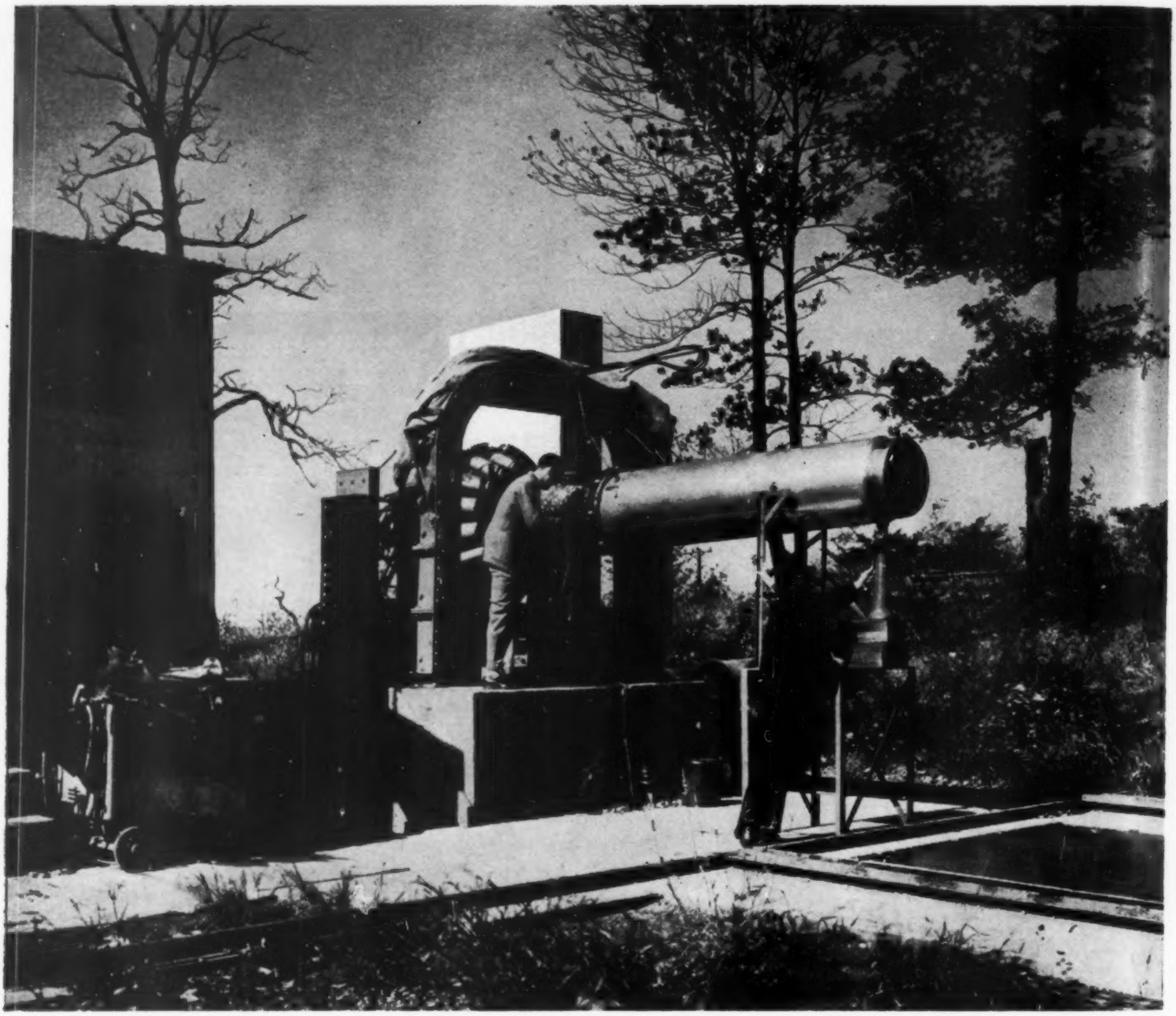
THE GATES RUBBER COMPANY
DENVER, U.S.A.

Gates Engineering Offices and Jobber Stocks are located in all industrial centers of the United States and Canada, and in 70 other countries throughout the world.



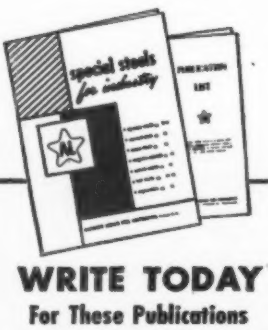
Typical Gates Vulco Rope Drive—the Gates V-Belts are built with Concave Sides to insure longer belt wear.

CS-5-3



It's the Test by Fire for High Alloy Steel

A jet engine on a test stand represents the kind of metal-killing service that no steel could stand until A-L pioneered in suitable high-temperature alloys. Then, *and only then*, came aircraft superchargers, jet and rocket engines, gas turbines, etc. ● You may have a problem of corrosion or heat resistance—of strength with light weight—or of special electrical requirements. The right special alloy steel can solve it, and we're the people to see. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***



WRITE TODAY

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1. SPECIAL STEELS FOR INDUSTRY . . . 16 pages of essential data on the proper selection and application of principal AL special alloy products: stainless, tool and electrical steels and sintered carbides.

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PIONEERING on the Horizons of Steel

Allegheny Ludlum

AL LEADING PRODUCER HIGH-ALLOY STEELS

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ACCURATE

From the largest bomber to the smallest helicopter MECHANICS Roller Bearing UNIVERSAL JOINTS *accuracy* has met every aircraft need. Designs, metals, machining, tolerances, heat treating, hardening, balancing and lubrication—all have been specifically adapted for aircraft precision. Let MECHANICS universal joint engineers help solve *your* control and power transmission problems. Our new catalog, containing helpful universal joint engineering data and tracing kits, will be sent to engineers, upon request.

MECHANICS UNIVERSAL JOINT DIVISION
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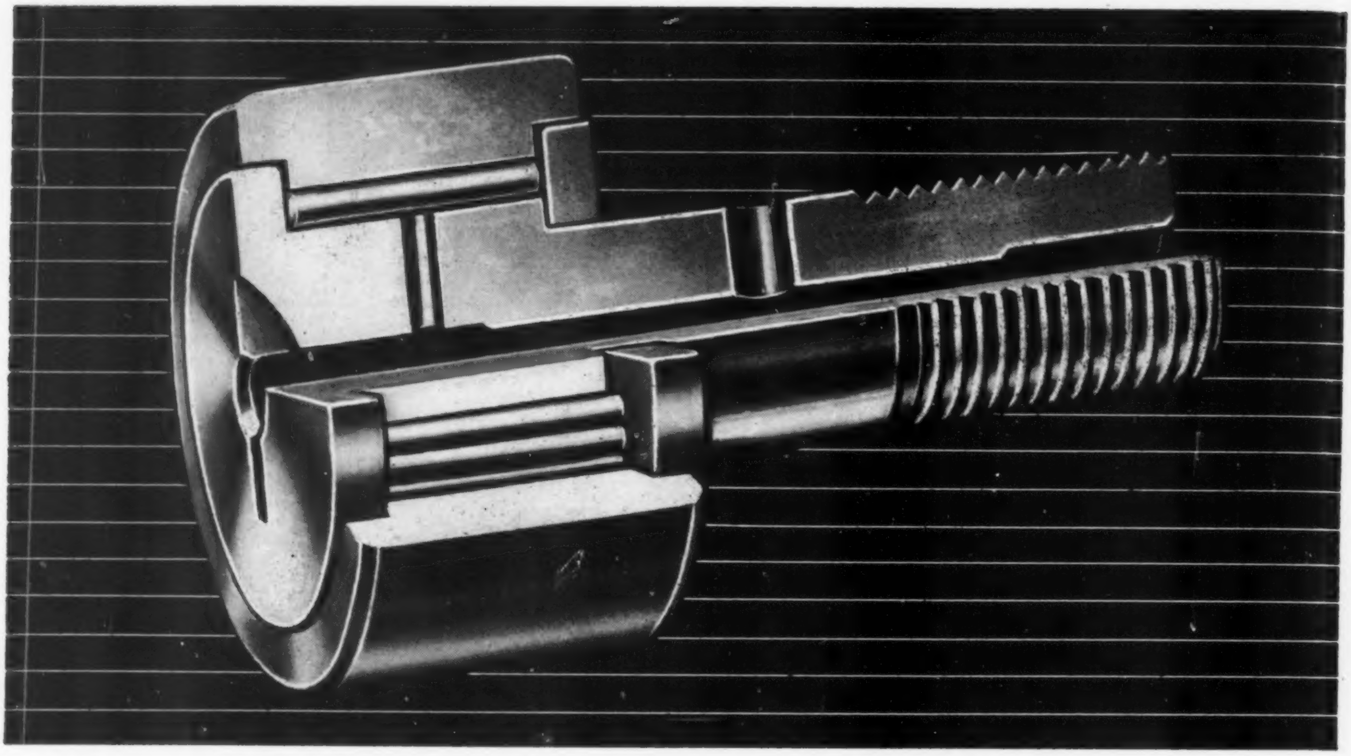
UNIVERSAL JOINTS

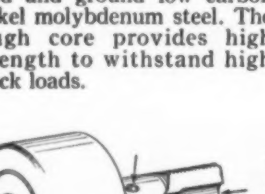
B-W

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment



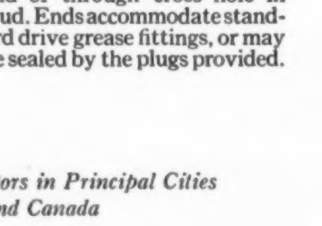
TORRINGTON CAM FOLLOWERS

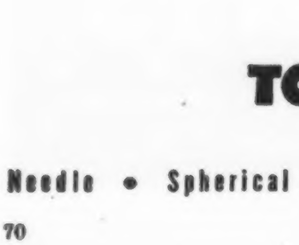
Give Longer Service... Carry High Shock Loads



1. Heavy sectioned outer race of hardened and ground high carbon chrome steel assures uniform distribution of high rolling and shock loads while providing high capacity anti-friction performance.

2. Integral stud for cantilever mounting is made of case hardened and ground low carbon nickel molybdenum steel. The tough core provides high strength to withstand high shock loads.

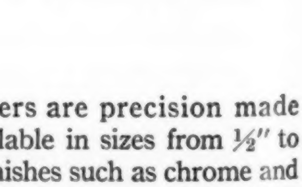


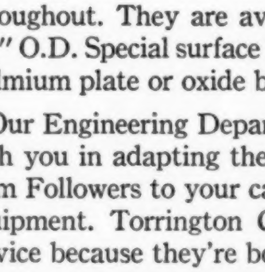


3. Easily relubricated at any one of three points—at either end or through cross hole in stud. Ends accommodate standard drive grease fittings, or may be sealed by the plugs provided.

District Offices and Distributors in Principal Cities of United States and Canada

4. Full complement of small diameter rollers—through-hardened, ground and lapped—for maximum radial load capacity.





5. Raceways precision ground for even load distribution (A) and uniform low end play (B) assure long bearing life.

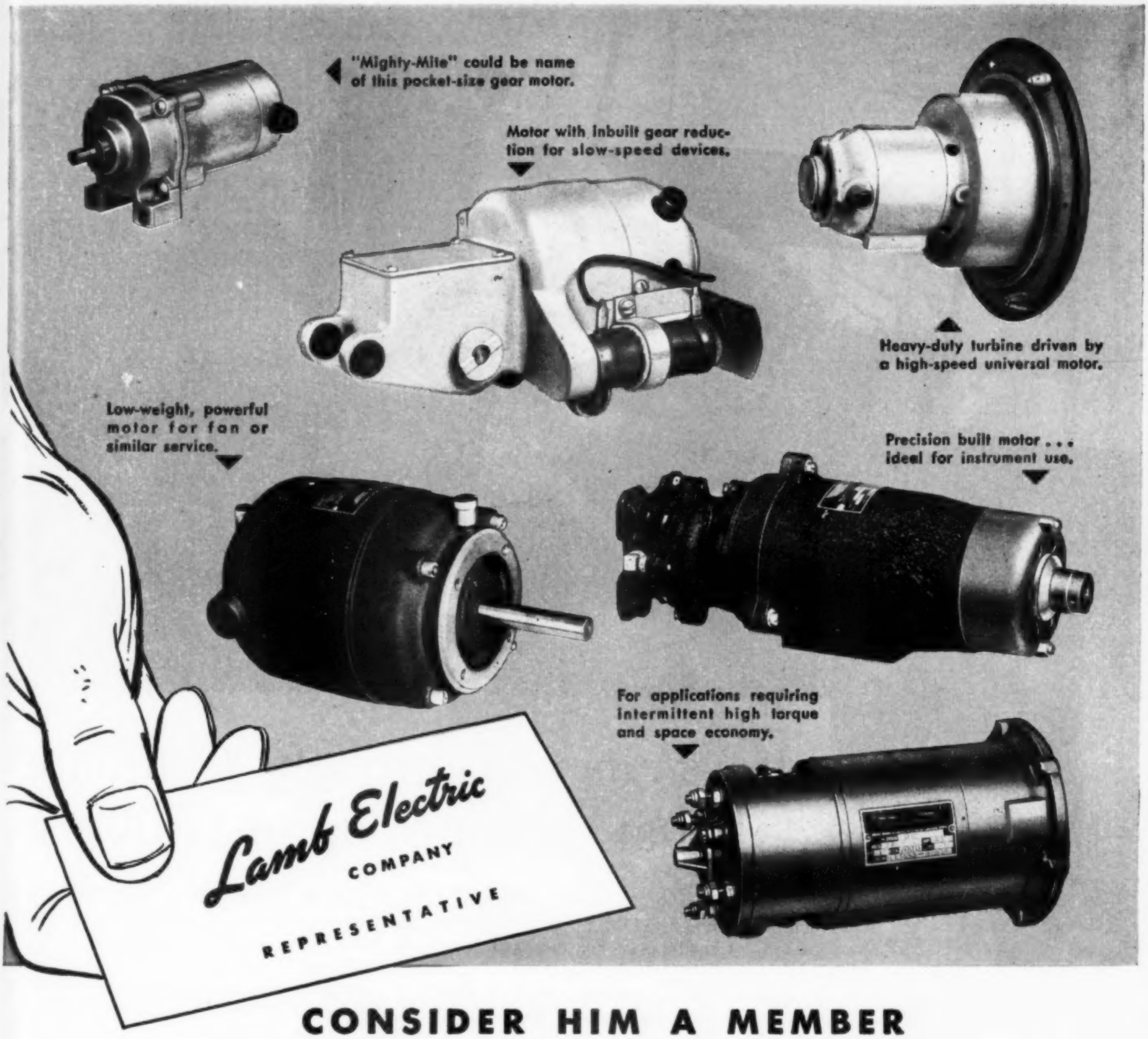
Torrington Cam Followers are precision made throughout. They are available in sizes from ½″ to 2¼″ O.D. Special surface finishes such as chrome and cadmium plate or oxide black can be provided.

Our Engineering Department will be glad to work with you in adapting these dependable and efficient Cam Followers to your cam-controlled or track-type equipment. Torrington Cam Followers give better service because they're better made.

THE TORRINGTON COMPANY
Torrington, Conn. **South Bend 21, Ind.**

TORRINGTON *NEEDLE* BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers



CONSIDER HIM A MEMBER OF YOUR *Engineering Staff*...

Many companies are finding it quite helpful to call in the Lamb Electric district engineer for suggestions, when designing a new motor-driven product or redesigning an existing one.

Through close cooperation of the manufacturer's engineering department and Lamb Electric engineers, such advantages as reduced costs, improved appearance, greater compactness and lower weight are often obtained.

The time to realize the full benefit of this teamwork is while your product is still in the blueprint stage.

THE LAMB ELECTRIC COMPANY
KENT, OHIO

In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

Lamb Electric
SPECIAL APPLICATION
FRACTIONAL HORSEPOWER
MOTORS

THEY'RE POWERING AMERICA'S *Finest* PRODUCTS

It gets its fuel through 1/4" tubing at pressures up to 1,700 psi

Meet the "Boss of the Crawlers"—Caterpillar Tractor Co.'s new 150 D.B. hp giant that toys with tons of earth, plays marbles with huge boulders, topples trees like tenpins.

Superior Tube supplies metal gullets through which such landscape levelers gulp their fuel.

Through ¼ inch O.D. tubing, diesel fuel is injected to cylinders at pressures up to 1,700 psi. So fuel injection tubing must be clean, have tremendous burst strength and resistance to fatigue. To meet Caterpillar's stringent specifications, Superior selects C-1008 Low Carbon Steel Tubing, draws it to size 250/255" O.D. x 0575/0675" I.D., then tests its mechanical properties to the utmost.

Result: heavy wall tubing with Rockwell hardness of B-65 maximum—capable of being cold upset without difficulty and cold formed into loops and bends without excessive spring-back. Bore is of uniform diameter, smooth and specially cleaned, and fracture testing and inspection at 15 power magnification assure freedom from cracks or seams of a depth greater than 5/1000 of an inch!

Scrupulous care in preparing, drawing and testing other grades of alloy and stainless Superior tubing makes them first choice for lubricating and cooling lines, governor shafts, valve spacers and valve push rods. One of our more than 55 analyses should be *your* choice, too, if you need trustworthy tubing and special help in adapting it to your use. Write us about your current tubing problem. We'll send you complete information and the appropriate catalog or technical bulletin by return mail. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Round and Shaped Tubing Available in Carbon, Alloy and Stainless Steels; Nickel and Nickel Alloys; Beryllium Copper; Titanium; Zirconium.

All analyses .010" to ⅝" O.D. Certain analyses in light walls up to 2½" O.D.

Superior Tube

The big name in small tubing

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. RAymond 3-1331

THEY'RE LAUNCHING THE world's deadliest fish

It's the revolutionary *U.S.S. Nautilus,* world's first atomic-powered submarine and fastest recruit ever to join America's underseas fleet.

Built by the Electric Boat Division of the General Dynamics Corporation, the *Nautilus* can travel around the world completely submerged, surface to attack the enemy, then dive under water to race away at a speed that defies pursuit.

Naturally, every component of the *Nautilus,* down to the last bolt, had to meet tough specifications. They weren't too tough, however, for the Ward Leonard electric control components and equipment installed.

Point is, when you want truly dependable performance from an electric control – whether it's for an atomic sub, an electronic computer or a traffic light – take your pick from the complete Ward Leonard line. And check the other side of this page for the story behind the fine reputation of Ward Leonard resistors.

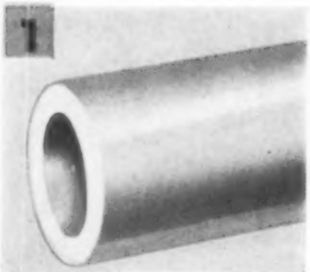
4.8

WARD LEONARD ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

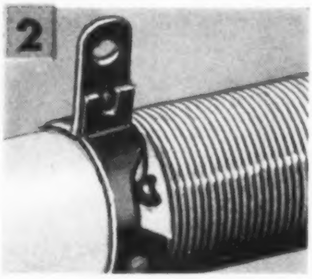
RHEOSTATS | RESISTORS | RELAYS | MOTOR CONTROLS | DIMMERS | CHROMASTER

Result-Engineered Controls Since 1892

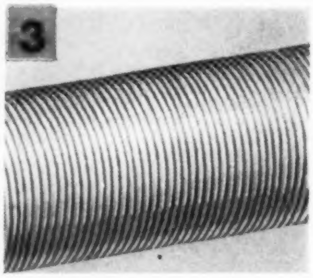
Why Ward Leonard resistors give you MORE FOR YOUR MONEY



RESISTOR CORE. Ward Leonard's own manufactured cores are perfectly smooth, cylindrical ceramic bodies of high density, low porosity, and high dielectric strength. The ceramic material has been selected so that its thermal coefficient of expansion is correlated to that of the other components.



TERMINALS. In Ward Leonard resistors, special alloy terminals insure proper expansion and adherence to the enamel, are designed to provide strong anchorage. Every wire-to-terminal junction is firmly clamped to the core, then specially silver-brazed for lasting contact.

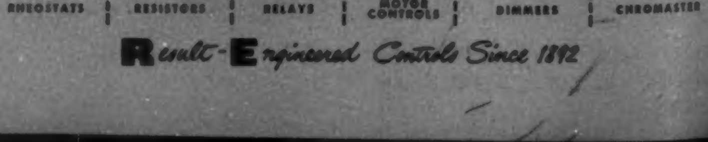


RESISTANCE WIRE. All wire is drawn to our own specifications for each particular resistor type. It's capable of withstanding heavy overloads, has a uniformly low coefficient of resistivity. Many of the "bargain" resistors are wound with resistance wire of ordinary grade.

COATING. Vitrohm enamel coating of all Ward Leonard resistors provides a complete hermetic seal — highly resistant to shock, high humidity, extreme temperatures, acids, alkalies, and electrolysis. Unlike most resistor manufacturers, we manufacture our own vitreous enamel.

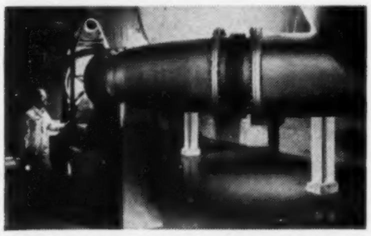
Our new 64-page Catalog 15 tells you more about the Vitrohm line of power resistors. It also includes many helpful charts and data. Write for it today to Ward Leonard Electric Company, 500 South Street, Mount Vernon, New York.

WARD LEONARD ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

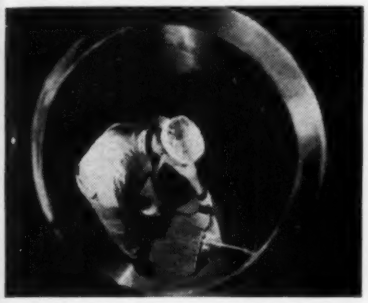


Result-Engineered Controls Since 1892

HEAT RESISTANCE: ENDURO can handle gases from full scale thermal jet engines, reciprocating engines, turbines, burners and other equipment tested in simulated high altitude conditions.



CORROSION-RESISTANCE: This is one of ENDURO's best known qualities. Installations of various types over the past thirty years offer visible proof that ENDURO stands up under some of the toughest corrosive conditions.



CLEANABILITY: ENDURO's high resistance to radioactive matter makes it a choice for equipment where this material is used. The answer is its smooth finish which offers little surface to which particles can cling.

Here's how they're using some of Enduro's properties

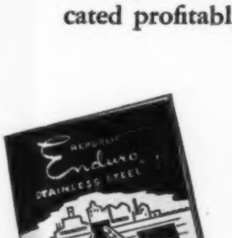
Aviation design engineers have long used ENDURO Stainless Steel for its high strength-to-weight ratio. Its resistance to high as well as sub-zero temperatures.

Now, designers in other fields are discovering new uses for ENDURO. For its remarkable ease of cleaning. For its satin luster. For its high resistance to rust and corrosion.

Management likes ENDURO, too. It can be fabricated profitably. And it gives extra sales features to products which might otherwise be lost in the shuffle.

No other commercial metal offers such a unique combination of physical and chemical properties as ENDURO Stainless Steel, the metal of 10,000 uses. Republic will be glad to help you use it... profitably. Write to:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, New York



FREE

This 36-page booklet gives properties, fabricating and joining methods, care and finishing of ENDURO Stainless Steels. Write for it. Ask for ADV. 561.

REPUBLIC STEEL

REPUBLIC
ENDURO STAINLESS STEEL

Other Republic Products include Carbon and Alloy Steels — Titanium — Pipe, Sheets, Strip, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Keyed...to your cost problems

One key that solves production and cost problems...that improves plant efficiency...is a fresh viewpoint, a new idea.

There's where the specialized services of your Chain Belt Field Sales Engineer can help you. His broad application knowledge...his familiarity with your problems...and the efficient performance of Chain Belt Products can help you find the right key to your problems.

for example: A lift truck manufacturer was seeking a way to reduce over-all costs. His CHAIN Belt Man suggested a change from standard roller chain to leaf chain. Result: lower cost and actually improved performance...far greater strength and life.

for example: A manufacturer of construction equipment was having field complaints about chain failure...with resultant excessive factory replacement costs. His CHAIN Belt Man suggested a change that solved the problem ...improved over-all performance.

for example: A conveyor manufacturer was trying to cut costs to achieve a more competitive price. His CHAIN Belt Man suggested a change from special roller chain attachment links to standard... reducing costs...with no loss of efficiency or life.

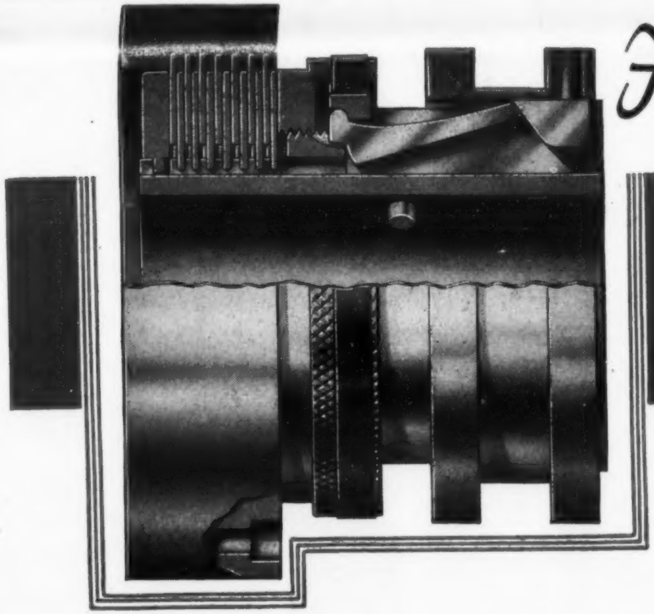
Often your CHAIN Belt Man can provide the "key" to your problems. Because he can offer all the advantages of a complete line of drive and conveyor chains, sprockets, attachments, roller bearings and couplings, he can recommend, without prejudice, the exact size and type that will help you cut costs. See him, or write Chain Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis.

CHAIN BELT COMPANY

District Sales Offices in all Principal Cities

For MACHINE TOOLS...MACHINERY...PRODUCT DESIGN... *Specify*

MAXITORQ *floating disc* CLUTCH



There are 2 basic types of Maxitorq clutches . . . Single and Double. Above is a cut-away view of the single type . . . the double is shown at right. Each is available in 8 capacities (wet or dry) from 1/4 to 15 h.p. @ 100 r.p.m. And from 13 to 788 max. working torque ft. lbs. Pulley type, Ring type, or Cut-off Coupling Driving Cups are also available.

The Maxitorq automatic overload release clutch (up to 5 h.p.) is extremely useful for protection of machine and product against accidental overload in high speed production. Special bulletin on request.

Send for Catalog No. MD-12

We hope you haven't minded turning this magazine around, but it was the only proper way to include the picture at the bottom. It clearly shows all parts of a single Maxitorq Clutch...and how easy it is to adjust it, take it apart, and assemble it...manually.

Each and every part contributes to smooth, positive, trouble-free clutch operation. The Separator Springs between each pair of inner discs keep them "floating" in neutral...preventing drag, abrasion, and heat. A Locking Plate locks all discs against the tension of the Separator Springs. The Adjusting Ring provides the means for obtaining the desired shifting pressure.

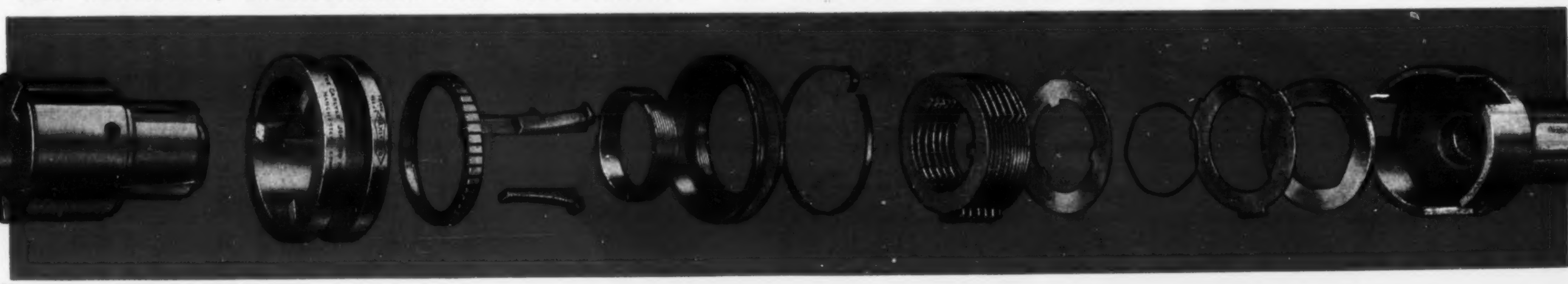
These are some of the reasons why we counted 69 machines, exhibited at the last Machine Tool Show, that were equipped with Maxitorq floating disc clutches. Send for our 50th Anniversary Catalog...and see how Maxitorq answers your problems for dependable power transmission.

THE CARLYLE JOHNSON MACHINE CO.
MANCHESTER, CONNECTICUT

Compact, rugged construction and precise machining . . . flat, true surfaces on engaging faces of the discs . . . provide not only the exacting accuracy required in important industrial machines, but also long, profitable service life.

Our engineers will give you personal assistance for correct selection of the right clutch and installation for your specific requirement.

ALL ASSEMBLY, DISASSEMBLY AND ADJUSTMENTS ARE MANUAL. CLUTCHES SHIPPED ASSEMBLED ON THE BODY.



4CJ83

MICRO SWITCH Precision Switches
A PRINCIPLE OF GOOD DESIGN

Operate over 57,000 times a day?

What do YOU want a PRECISION SWITCH to do?

Have high repeat accuracy?

Provide high electrical capacity?

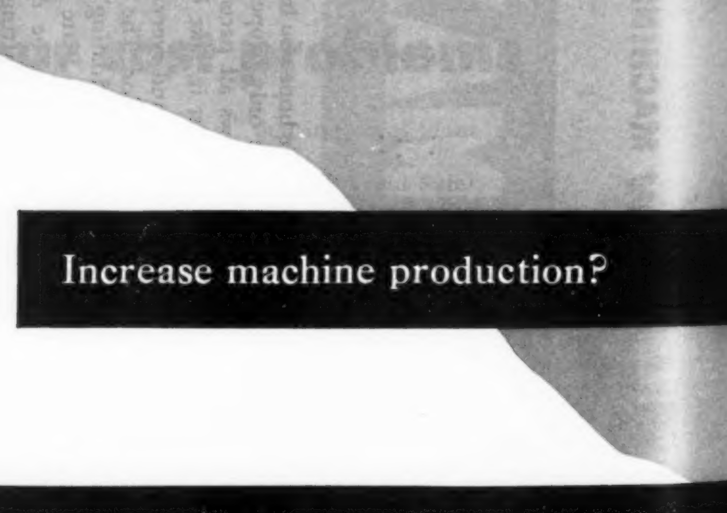
Increase machine production?

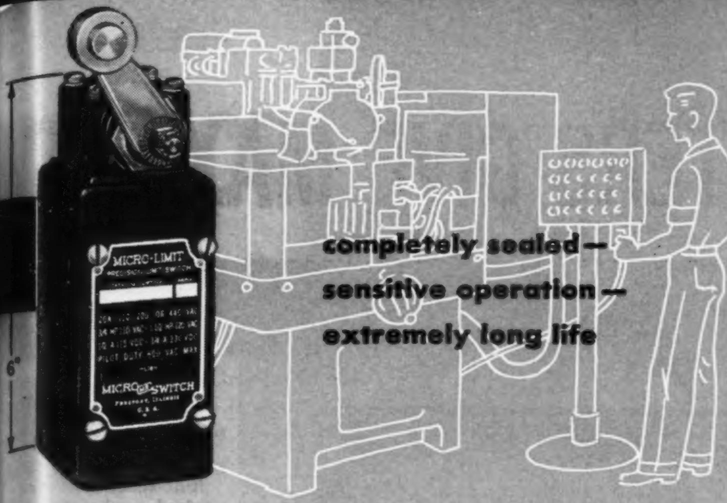
extremely small—
require small motion—
fully dependable

Contribute to small, streamlined design?

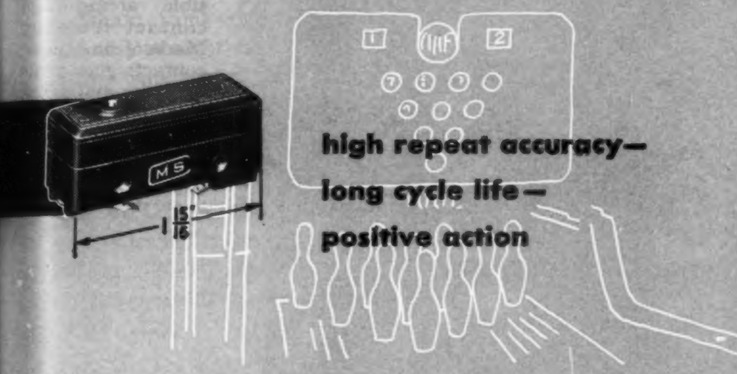
Two of these subminiature switches helped make possible the streamlined design and superior performance of one of the business wonders of the day—the V. P. Voicewriter of Thomas A. Edison, Inc. Edison engineers liked the small size—just over ¾ inch long—the small motion requirements, long-life dependability and the approved use for 110 volt ac current. This is the smallest, lightest precision switch ever built. What do you want a precision switch to do?

A complete line of snap-action and mercury switches

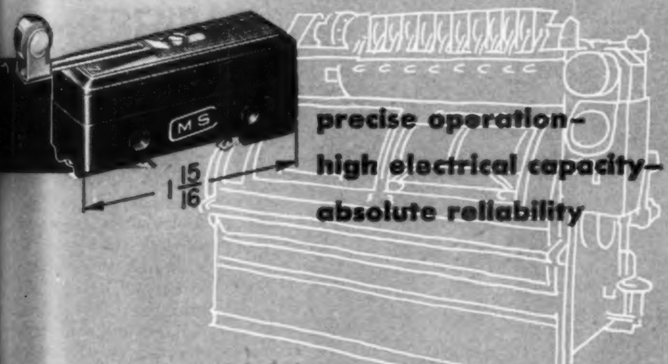




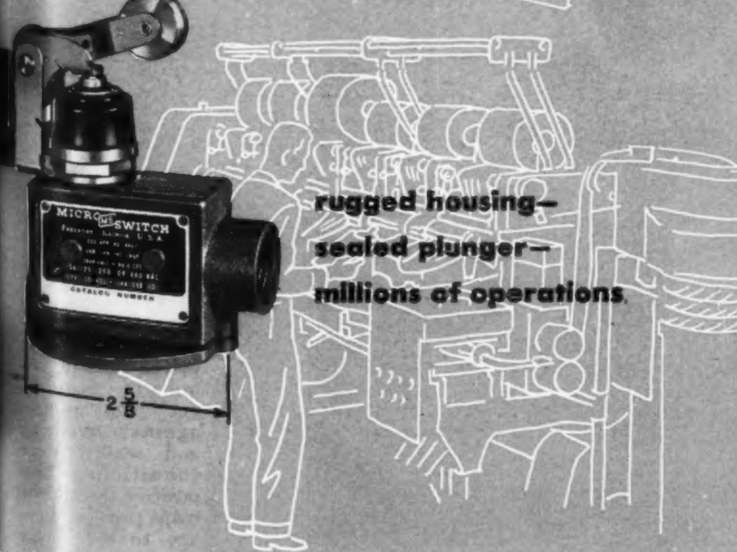
• Here's one of seventeen heavy duty limit switches that control the finish grinding of small parts in a DoALL Automatic Grinder. Some of them operate every 1½ seconds—or 57,600 operations in a 24 hour day. The versatile adjustment of the roller arm permitted mounting these switches in minimum space. This switch is available in SPDT or two-circuit contact arrangement. There's a MICRO SWITCH precision switch to meet YOUR most exacting requirement—and field engineers in 16 branch offices to help you find it.



• Fifteen MICRO SWITCH precision switches control every action of this automatic pin setting machine developed by American Machine & Foundry Company engineers. This unit sets the pins and returns the ball more efficiently than possible with hand operation. High repeat accuracy and long cycle life were the special features of the switches selected by AMF engineers. If you make—or plan to make—products which call for a precision switch application it will pay you to consult a MICRO SWITCH field engineer. Call or write the nearest branch.



• A completely automatic commercial washer—the first ever produced—is the product of ROBOT Laundry Machinery Division of The Wolf Company. ROBOT engineers chose 24 MICRO SWITCH precision switches of eight different types to control every step of the laundering process automatically. Long-life dependability, high electrical capacity and precise accuracy of these MICRO SWITCH products dictated their choice. Need a switch for a new product—or to make a present product better? A call to MICRO SWITCH can save time and money.



• This comber of the Terrell Machine Company combs 36 to 40 pounds of 12" lap per hour with ten MICRO SWITCH precision switches as controls. The high production is facilitated by the use of six switches to control the trumpet stops on the combing heads. Four other switches control the mechanisms for coil changing, stopping and timing. Terrell engineers picked MICRO SWITCH units because of their small size, rugged construction and long-life precision. There's a MICRO SWITCH precision switch for every design need. Let our field engineers help select the switch for you.

MICRO SWITCH provides a complete line of extremely reliable, small-size, high-capacity, snap-action precision switches and mercury switches. Available in a wide variety of sizes, shapes, weights, actuators and electrical characteristics. For all types of electrical controls.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

FREEPORT, ILLINOIS

H
HONEYWELL

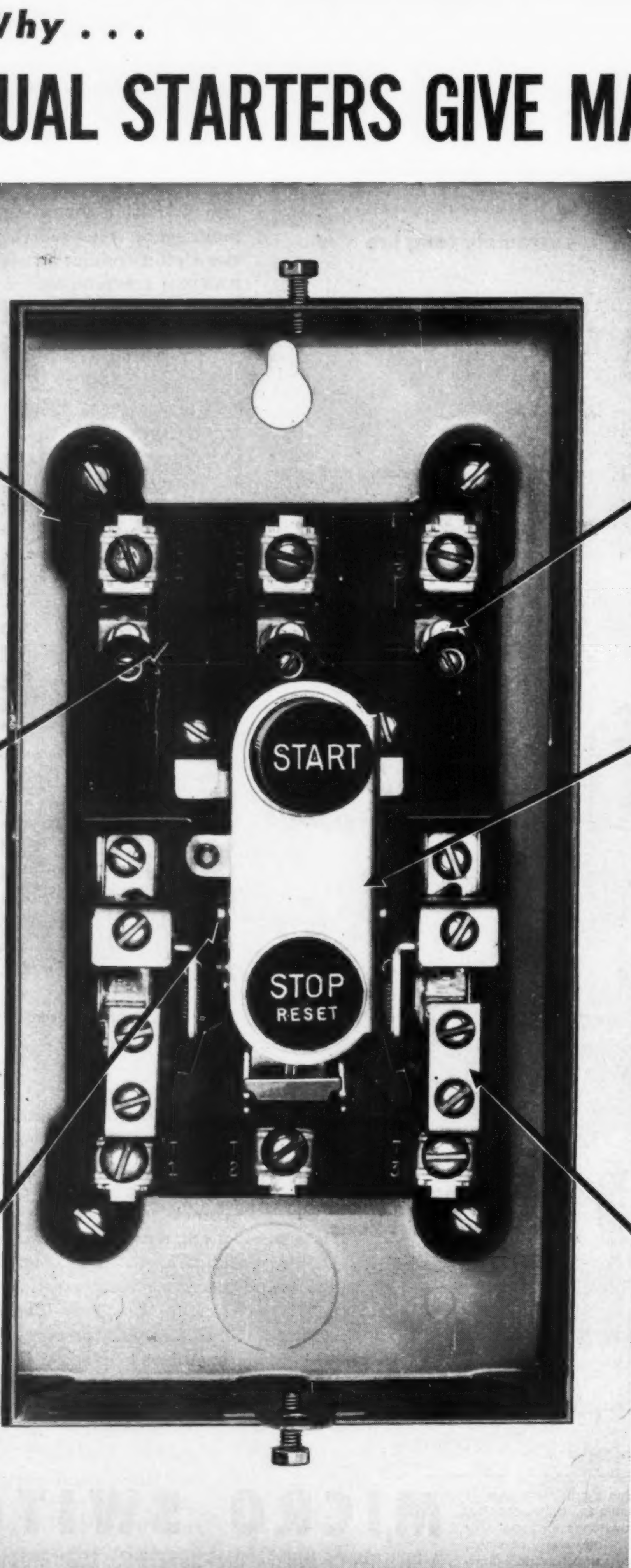
6 Reasons Why . . .

G-E MANUAL STARTERS GIVE MAXIMUM PR

INSULATED BASE. The starter's molded insulated base provides maximum protection from grounding. Barriers to isolate contacts and reduce arcing are made from hot molded material which doesn't absorb moisture. They have sufficient protection against arc-overs, and also act as mounting supports for the switch.

ARC PROTECTION. Arcs are completely confined, even with maximum horsepower and stalled rotor current, in deep insulated wells. This feature provides a high safety factor by reducing the possibility of arc-over between adjacent contacts and results in increased contact life.

SAFE FROM VIBRATION. The snap-action switch mechanism is built so it cannot accidentally trip from machine vibration. Both push button and lever types help protect against inadvertent operation. Guard on toggle-type switch cover prevents accidental tripping, yet is large enough for operation by a gloved finger. The handle guard provides a means for padlocking switch in either ON or OFF position. For fractional horsepower motor switches, a new handle guard incorporating these safety features is available.



SPLIT-SECOND BREAK. Operating mechanism is spring-loaded for split-second breaks which reduce possible arcing and contact freezing. Made of fine silver, contacts give years of make and break operations. Large contact surface assures positive contact on make.

TRIP-FREE MECHANISM. On G-E manual starters, the operating mechanism trips free on overload, opening the contacts. This action makes it impossible for the switch to be held closed under injurious overload conditions. Visual indication is given by the lever or push button in the neutral position.

NO INJURIOUS OVERLOADS. Bi-metallic overload relays allow your motor to deliver maximum power without premature tripping, yet help protect against overloads and stalled rotor conditions. This positive protection helps prevent damage to the motor due to heating. Bi-metallic overload relays, unlike the solder-pot type, can be mounted in any position. Easily installed heaters are available in all ratings.

PROTECTION

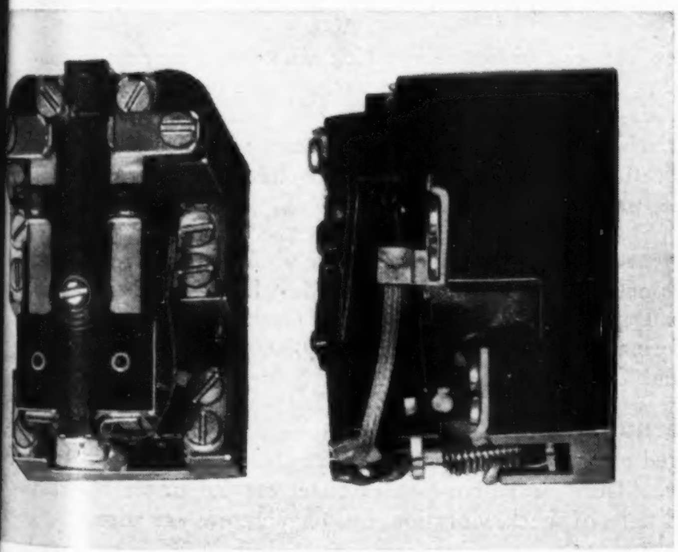
laximum protection, inside and out, is rovided by G-E manual starters. In addi- on to the features illustrated at left, pro- ctive devices have been built into the en- osure itself. Provision has been made for adlocking starter cover (toggle types may lso be padlocked in ON or OFF position) help protect personnel.

ADDITIONAL FEATURES of G-E manual tarters include front-connected, clamp- ype terminals; straight-thru wiring; gen- ral purpose, water-tight, dust-tight and xplosion-proof enclosures; clearly marked ne and load terminals; and operating echanisms that are replaceable as units.

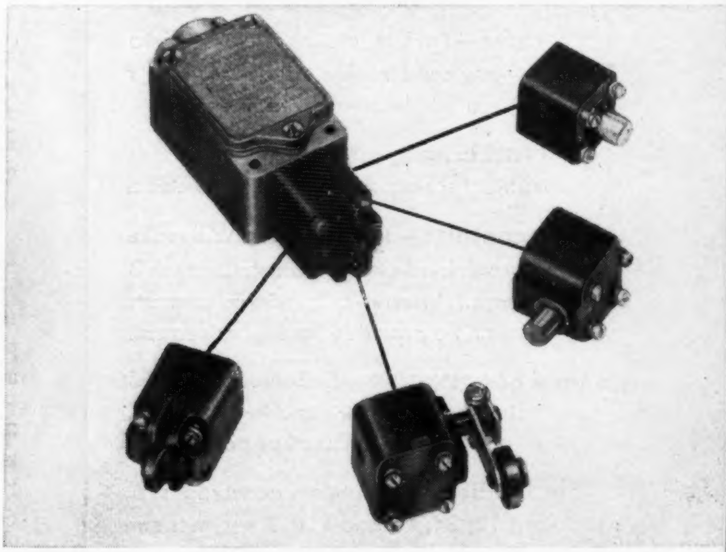
FOR MORE INFORMATION contact your earest G-E Sales Office, or Distributor, or rite Section 730-54, General Electric Company, Schenectady 5, N. Y. Ask for Bulletin GEA-1522.

EASILY ACCESSIBLE MOUNTING KNOCKOUTS in top, sides, bottom and back of case simplify installation. Knockouts are punched for ½ or ¾ inch conduits. Straight-thru wiring, adequate wiring space and saddle-type clamping terminals make wiring easy.

DEPENDABLE RELAYS, LIMIT SWITCHES FOR VARIED APPLICATIONS

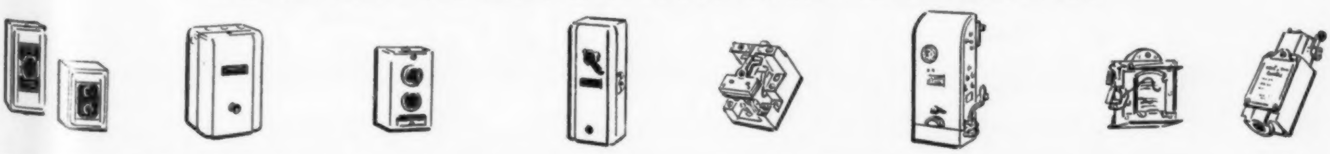


Small size, general-purpose relays are high current rated. Both a-c and d-c forms are available in ratings up to 300 volts. The new, strong, long-life shunt assures dependable relay performance.



Compact, track-type limit switch has four interchangeable heads: roller lever, side pushrod, top pushrod, and roller push-rod. Heads mount in any of four 90-degree operating positions.

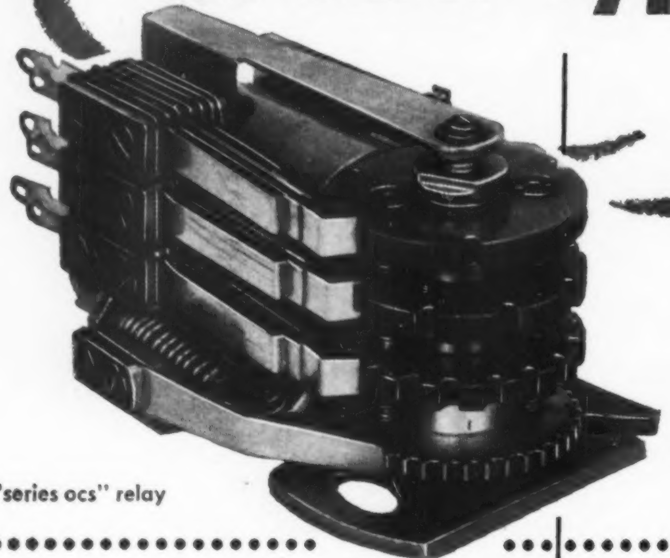
CHOOSE FROM THE COMPLETE GENERAL-PURPOSE CONTROL LINE



MANUAL STARTERS — MAGNETIC STARTERS — PUSH BUTTONS — COMBINATION STARTERS — RELAYS — REDUCED VOLTAGE STARTERS — SOLENOIDS — LIMIT SWITCHES

GENERAL ELECTRIC

new cam-type relay



"series ocs" relay

"series ocs" combines relay and stepping switch functions

"OCS" RELAY SPECIFICATIONS

cams—Each revolution is divided into 36 steps—any combination of "operated" or "unoperated" intervals can be provided.

contact arrangement—Maximum of 6 contact springs for each of the 3 cams.

spring contacts—Twin contacts. Will make and break load of 150 watts (maximum 3 amps.). "Heavy-duty" single contacts can be provided for higher current.

speed of operation—Self-interrupted, 65 steps per second; impulse-controlled, 30 steps per second.

voltages—Nominal dc voltages: 6, 12, 24, 48 and 110. A rectifier can be furnished for 115 volt, ac, 60 cycles.

vibration—Withstands up to 10.5 G.

shock and acceleration—Up to 25 G.

ambient temperatures— −55°C. to +75°C.

weight—14-20 oz.

size—3¼" x 2-7/16" x 1-25/32".

. . . PROGRAMMING IS CUSTOM-DESIGNED

Here's a shock-resistant relay which can be used for cam-switching . . . for alternate on-off operations . . . or as a "stepper". *You* specify the programming when you order Automatic Electric's "OCS" Relay—select a contact sequence to fit *your* applications. This compact unit simplifies engineering—cuts space, weight, maintenance costs.

cam-switching — You can replace whole banks of relays and combinations of relays and stepping switches with this versatile unit. Dependability of the stepping mechanism is proved by performance records exceeding 250,000,000 high-speed operations! That's really performance!

alternate on-off operations — You can specify this rugged new relay as a replacement for the delicate latch-in type relay. "OCS" will give you excellent service under extreme conditions of shock, vibration, and temperature variation.

stepping operations — Stepping is high-speed, accurate and dependable. Can be driven self-interruptedly to produce a time cycle or for "homing".

Complete data on Automatic Electric's new "OCS" Relay can extend the scope of your planning. Write today to: Automatic Electric Sales Corporation, 1033 West Van Buren Street, Chicago 7, Illinois. In Canada: Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

RELAYS **SWITCHES**

PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF

AUTOMATIC ELECTRIC

CHICAGO

Precision "O" Rings make these Quick-Connect couplings leak-proof!

Hydraulic, pneumatic and other fluid lines can be connected or disconnected quickly, easily and safely with the two-way shut-off couplings made by **The Hansen Manufacturing Company** of Cleveland. When connected the Hansen coupling permits a free flow through it—and a **Precision "O" Ring** makes the vital seal which insures a long life of leak-proof service.

Everywhere **Precision "O" Rings** are doing a big job, carefully inspected, high quality, tough, compression molded, they lick leakage! Let us help you.

FREE—Write for your personal copy of our Handbook on "O" Rings.

Precision Rubber Products CORPORATION

"O" Ring and Dyna-seal Specialists ®

Box 431, Dayton 7, Ohio Canadian Plant at: Ste. Thérèse de Blainville, Québec

2 High Hot Strip Mill Table Rolls in plant of Dominion Foundries and Steel Ltd., Hamilton, Ontario, Canada. Arrows indicate location of J-M Clipper Oil Seals which protect bearings against dirt and other adverse conditions.

Engineers at Dominion Foundries and Steel Hot Strip Mill report:

"Bearings better protected— damaging dirt sealed out with Clipper Seals"

TABLE ROLLS of the 2 high strip mill at Dominion Foundries and Steel Ltd. must operate efficiently despite severe service conditions. Life of the Roll Bearings is constantly threatened by dirt and salt from strip mill operations.

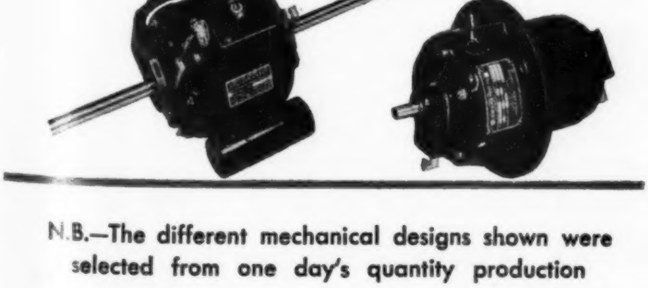
To provide better protection, engineers replaced the original bearing seals with J-M Clipper Oil Seals. Long after this installation was made, Clipper Oil Seals are still providing far better bearing protection than the material formerly used. They seal out mill scale, salt and other foreign matter which might work into the bearing housings. They remain efficient despite high oil and air temperatures. They protect bearings by assuring clean lubrication.

Clipper Oil Seals offer many advantages wherever accurate fit, longer life and greater sealing effectiveness are required. These precision-moulded oil seals provide easy installation because the tough, dense heel affords just the right amount of rigidity for a press fit in the cavity . . . while the flexible lip, held in light but positive contact with the shaft by an especially designed garter spring, provides effective sealing at all times.

Made in both split and endless types, Clipper Oil Seals are available in a wide variety of designs, to meet practically any sealing requirement. For complete details and literature write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ont.

Johns-Manville CLIPPER OIL SEALS

each of these HOLTZER-CABOT motors solved a special problem!



Holtzer-Cabot specializes in motor and generator design, and is tooled to produce both AC and DC motors and generators, in a wide range of frames, with unlimited varieties of mechanical and electrical features.

Quality motors correctly designed result in lowest ultimate cost.

Bring your small-motor application problem to Holtzer-Cabot. Our experience in developing custom-built motors assures you of a prompt and expert solution.

N.B.—The different mechanical designs shown were selected from one day's quantity production

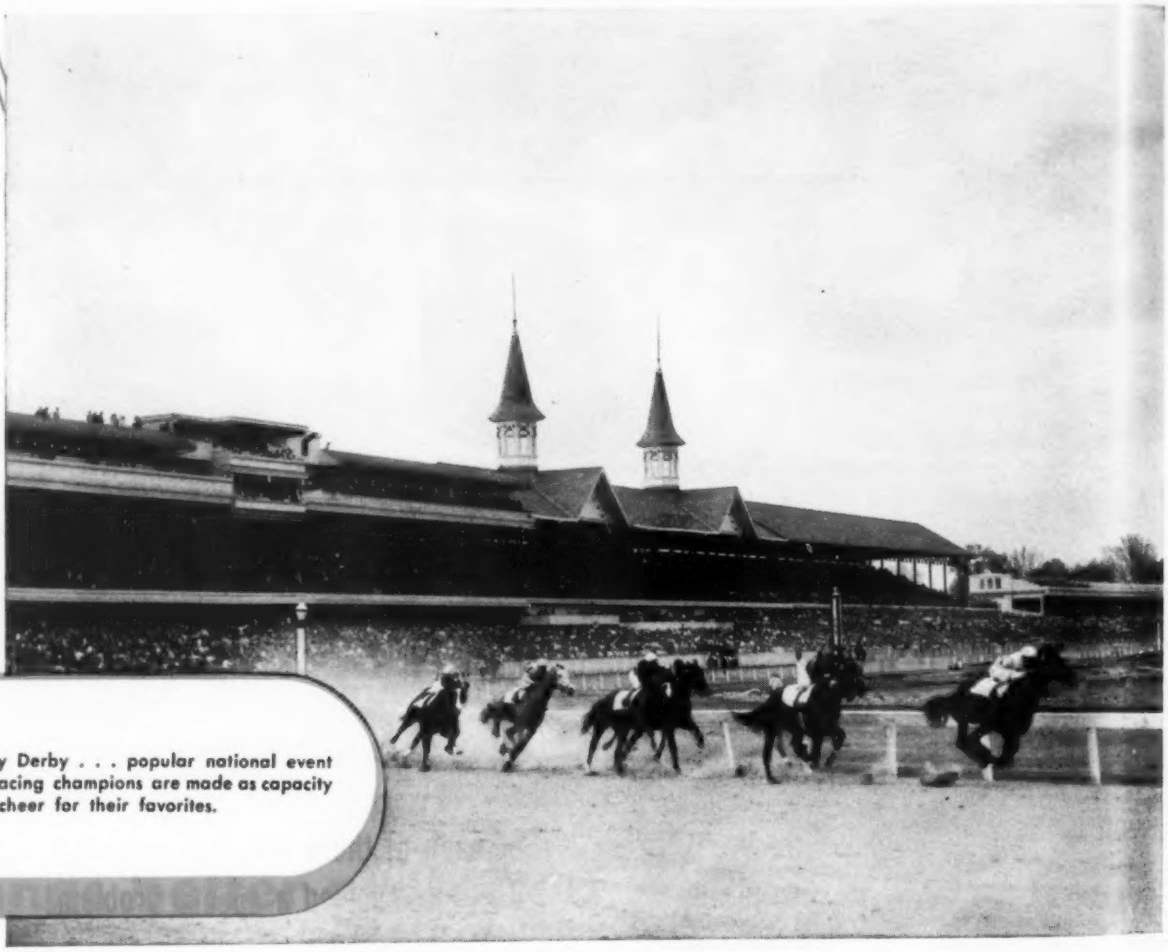
NATIONAL PNEUMATIC CO., INC. AND HOLTZER-CABOT DIVISIONS

125 Amory St., Boston 19, Mass.
Sales Service Representatives in Principal Cities throughout the World

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

LOGAN . . . a national participant in major fluid power advancements

SINCE 1916



Kentucky Derby . . . popular national event where racing champions are made as capacity crowds cheer for their favorites.

LOGAN AIR-DRAULIC® FEED-CONTROLLED CYLINDERS

POWER MOVEMENTS IN ANY DIRECTION — NO POWER UNIT REQUIRED

COMBINES

the fast-acting, economical low pressure operation of

AIR

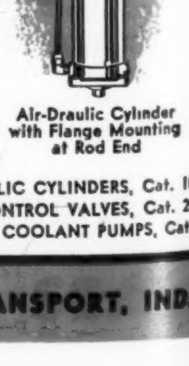
with the smooth, uniform controlled regulation of

OIL

5 STANDARD MOUNTING TYPES

Standard bores from 3" to 8". Any stroke to 5 feet. For air pressures to 150 p.s.i.

Furnished for controlled feed with rapid return in either direction, or with controlled feed in both directions. Skip-feed movement can also be provided.



Air-Draulic Cylinder with Flange Mounting at Rod End

LOGAN MANUFACTURES 6,975 STANDARD CATALOGED ITEMS

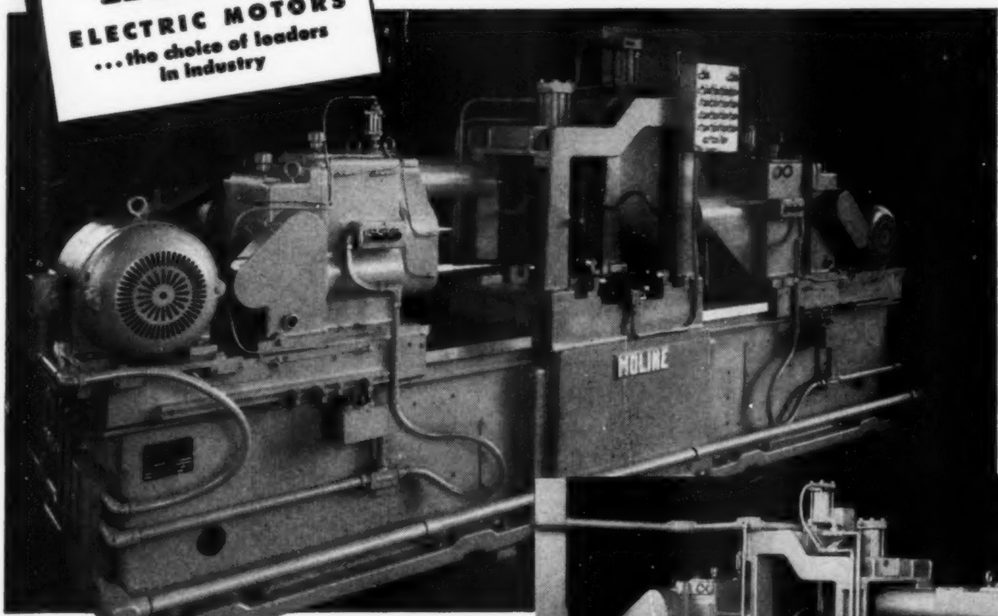
FREE CATALOG ON REQUEST

AIR CONTROL VALVES, Cat. 100-4 · AIR CHUCKS, Cat. 70-1 · AIR CYLINDERS, Cat. 100-1 · AIR-DRAULIC CYLINDERS, Cat. 100-3
AIR and HYDRAULIC PRESSES, Cat. 51 · COLLET GRIP TUBE FITTINGS, Cat. 200-5 · HYDRAULIC CONTROL VALVES, Cat. 200-4
HYDRAULIC CYLINDERS, Cats. 200-2; 200-3 · HYDRAULIC POWER UNITS, Cat. 200-1 · SURE-FLOW COOLANT PUMPS, Cat. 62

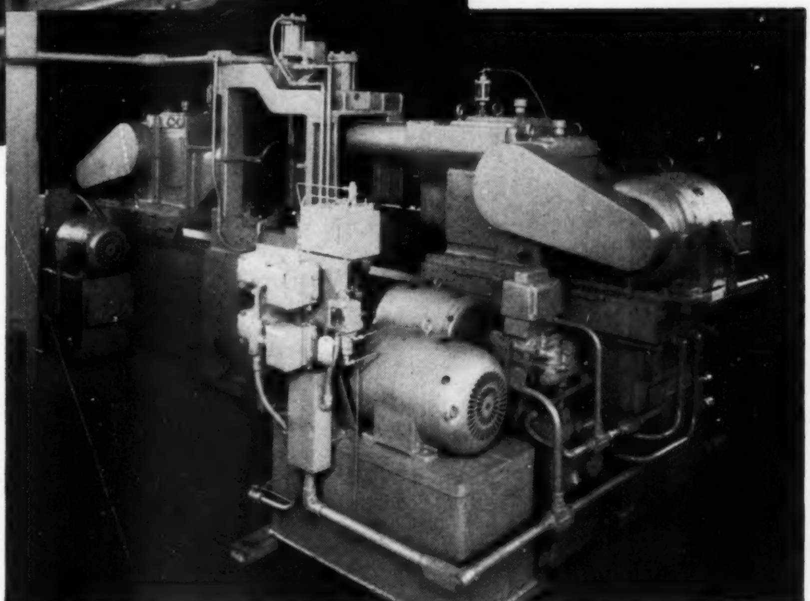
SAVES TIME · Logan · AIR AND HYDRAULIC EQUIPMENT · EFFORT · MOTION

LOGANSPORT MACHINE CO., INC., 811 CENTER AVE., LOGANSPORT, IND.

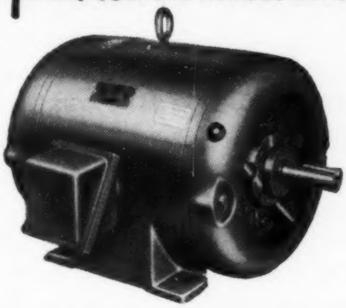
Wagner®
ELECTRIC MOTORS
. . . the choice of leaders in industry



Moline Tool Company No. MR 140 special boring machine for tractor clutch housings. The machine is equipped with five Wagner Type EP-1 motors, ranging from 3 to 10 hp.



Wagner Totally Enclosed MOTORS mean less down time for production machinery



Wagner totally-enclosed fan-cooled motors are available in either steel frame or cast iron frame construction, in standard or explosion-proof types, single-speed or multi-speed, 2 phase or 3 phase, in ratings to 250 horsepower.

This Moline two-way, four-spindle boring machine bores, counterbores, faces and chamfers the end holes in tractor clutch housings. Each machine is equipped with five Wagner totally-enclosed, fan-cooled motors (Type EP-1).

The extra protection built into these Wagner Motors means less down time for production machinery. They are totally-enclosed against damage from steel filings, chips, dust, dirt, fumes and moisture. They require no maintenance other than periodic lubrication.

Whatever your requirements may be, there is a Wagner Motor to fit every need—a complete line for all current specifications, with a wide variety of enclosure types and mountings. Bulletin MU-185 gives full information.

Your nearby Wagner engineer can help you select the *right* motors for your needs. Call the nearest of our 32 branch offices, or write us.

Wagner Electric Corporation
EST. WEC 1891

WAGNER ELECTRIC CORPORATION
6404 PLYMOUTH AVE., ST. LOUIS 14, MO., U.S.A.

ELECTRIC MOTORS
TRANSFORMERS
INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

H54-16

Here's good news for you

Precision

pins, blades, points, pivots, rollers, awls, dowels, mandrels, shafts, studs, punches, swagings, etc.

Torrington can make them *faster, better and for less* than you can yourself—in the temper, hardness, and micro-finish you want—to tolerances in tenths.

Send for our Condensed Catalog today. It shows many more parts that we can produce economically for you. And send us a sample part, a blueprint or a letter stating your needs. We're sure our quotation will be welcome news.

The Torrington Company
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TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

Take this common sense approach to PUMPS

Save Time, Money, Trouble

Get specific engineering help

You'll find it pays off in hard cash to standardize on reliable, low maintenance Allis-Chalmers pumps for all your needs. That's because your A-C representative is an experienced, highly qualified engineer who will give you full cooperation at every step of the way—from planning to purchasing to production. Being a specialist in individual pump applications, as well as OEM design and production problems, he can frequently make valuable suggestions which result in substantial savings in time, money and effort — improved performance of your product.

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PUMPS

Get immediate delivery from stock

A-C centrifugal pumps — in a broad range of types and sizes—are carried in stock by warehouses all over the country. Your A-C representative will show you how to expedite pump selection and ordering . . . make sure you get the exact units you require for maximum performance at lowest cost. Find out for yourself why more and more OEM's are standardizing on Allis-Chalmers Pumps. Get all the facts from your Allis-Chalmers district office.

A-4493

Electrifugal is an Allis-Chalmers trademark.

For literature on Allis-Chalmers
FHP Package Pumps get Bulletin 52B7529 . . . *Electrifugal* Pumps, Bulletin 52B6140 . . . Supporting Adaptor Pumps, Bulletin 52B6083 . . . Vertical Mounted Pumps, Bulletin 52B6975. Write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

A Hundred

or a MILLION pieces

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Cut to *Your* Precision Demands!

When Western Felt cuts a component part to your specifications, piece after piece is a precision-cut part. You want that kind of uniform precision because the performance of *your* product depends upon it. And because of the peculiar properties of wool felt fibres, especially where the more dense types are specified, it can be processed with amazingly close tolerances. Tolerances as close as a few-thousandths of an inch can be supplied when required.

Western Felts are manufactured to the density you require—cut and supplied exactly to your specifications. They resist wear, age and weather...never ravel nor fray. They seal, insulate, absorb sound and vibration, or lubricate...as you wish! Chemically treated, they can be moth-proof, mildew-proof, flame or water resistant.

You name it...specify it...we put the benefits of 54 years of experience back of making a felt component that will meet your specifications. Write today—your inquiry will receive prompt attention.

WESTERN *Felt* WORKS

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Manufacturers and Cutters of Wool Felt

New facts for your file on

USS HIGH STRENGTH STEELS

Built 1000 lbs. lighter with USS COR-TEN steel

dump trailer hauls more, costs less to operate, will last longer

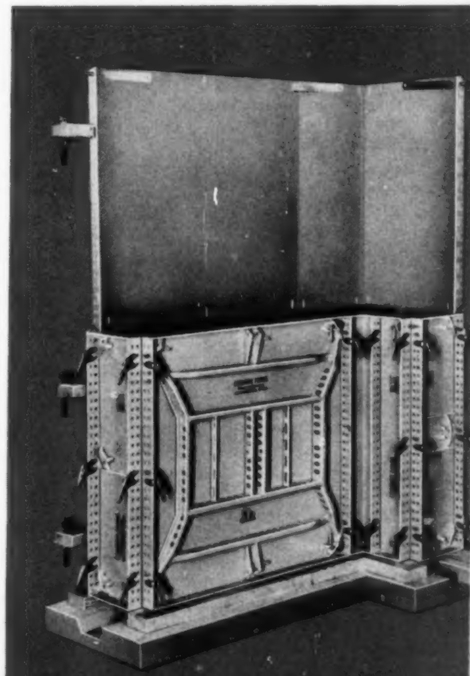
● At an extra cost of only thirty dollars for USS COR-TEN steel, the Trailmobile Co., Cincinnati, Ohio, has trimmed 1000 lbs. of deadweight off this 26½ cu. yd. dump trailer. As a result, it can haul one-half ton more payload without any increase in loaded weight over a similar unit built of ordinary steel, and operating costs per ton moved are materially reduced.

But USS COR-TEN steel does more than save weight and lower operating costs. Its high yield point of 50,000 psi—one and a half times that of carbon steel—gives the trailer body exceptional strength and toughness. Its much higher resistance to atmospheric corrosion, its superior resistance to abrasion, impact and wear greatly increase durability, keep the trailer on the job and help to prolong its life.

Since its introduction twenty years ago, USS COR-TEN steel has been used by 27 leading builders of trucks and trailers—names famous in the commercial car industry—to produce equipment that is lighter, more durable, able to do more work and cheaper to operate and maintain.

50% stronger and 20% lighter,

concrete forms of USS COR-TEN Steel last almost twice as long as carbon steel, materially reduce shipping costs



On many construction jobs, steel forms to hold concrete in place until it has hardened are now used instead of expensive wasteful forms built up of ordinary construction materials.

Such steel forms not only speed up work and save labor costs but, because they can be used over and over, save material as well.

A major producer of steel concrete forms is the Economy Forms Corporation, Des Moines, Iowa, which rents forms to contractors. This manufacturer reports that COR-TEN Steel used in their forms since 1948 has effected substantial savings because of its greater strength and higher corrosion resistance as compared to carbon steel.

For example, carbon steel forms, 30" x 30", can withstand a pressure of 1000 lbs. per sq. foot. They weigh 48 lbs. each and last about 6 years. In contrast, COR-TEN Steel forms of the same size, can withstand a pressure of 1,500 lbs. per sq. foot, but they weigh only 38 lbs. each and have a probable life of 8 years. The use of COR-TEN sheets for these forms has reduced the maintenance cost approximately 40%.

Concrete forms are shipped an average of ten times each year and here COR-TEN Steel forms pay further dividends because they weigh less.

Economy Forms Corporation estimates their freight savings to be 10¢ to 12¢ per sq. ft. per year, which runs into a pretty penny when you consider that they have 1,200,000 sq. ft. of forms in use.

USS

UNITED STATES STEEL COMPANY, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

New facts for your file on

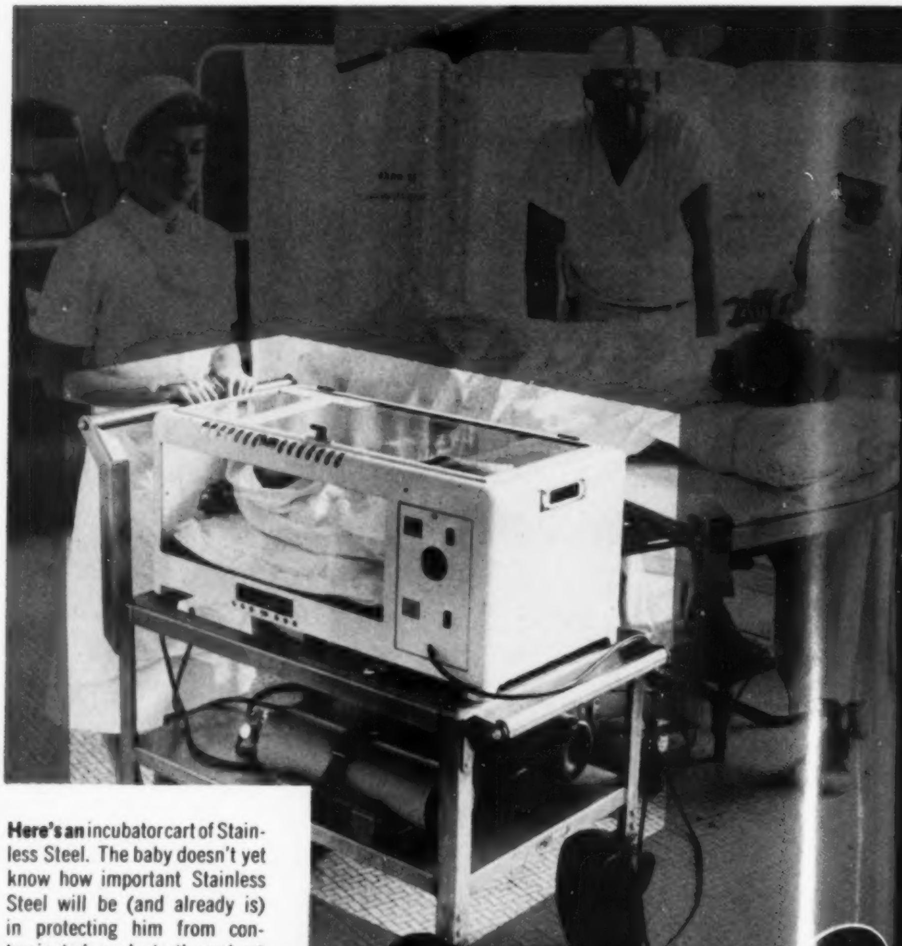
Hospitals depend upon Stainless Steel in kitchens and operating rooms...

This open-tray truck is also of Stainless Steel. So it will last longer and will be easy to keep clean and good-looking.

it's so easy to keep clean and sanitary

Stainless Steel equipment is vital to the operation of all modern hospitals. The Cook County Hospital in Chicago uses Stainless Steel extensively wherever equipment must be kept clean and sanitary. Only Stainless Steel is so dependably safe and so long lasting. It effectively resists rust and corrosion, is easy to keep clean and shining. All the Stainless products shown here are supplied by Colson Corporation of Elyria, Ohio.

Another shining example of Stainless Steel beauty, this battery of food conveyor trucks will see many years of trouble-free service in the Cook County Hospital kitchen.



Here's an incubator cart of Stainless Steel. The baby doesn't yet know how important Stainless Steel will be (and already is) in protecting him from contaminated products throughout his life.

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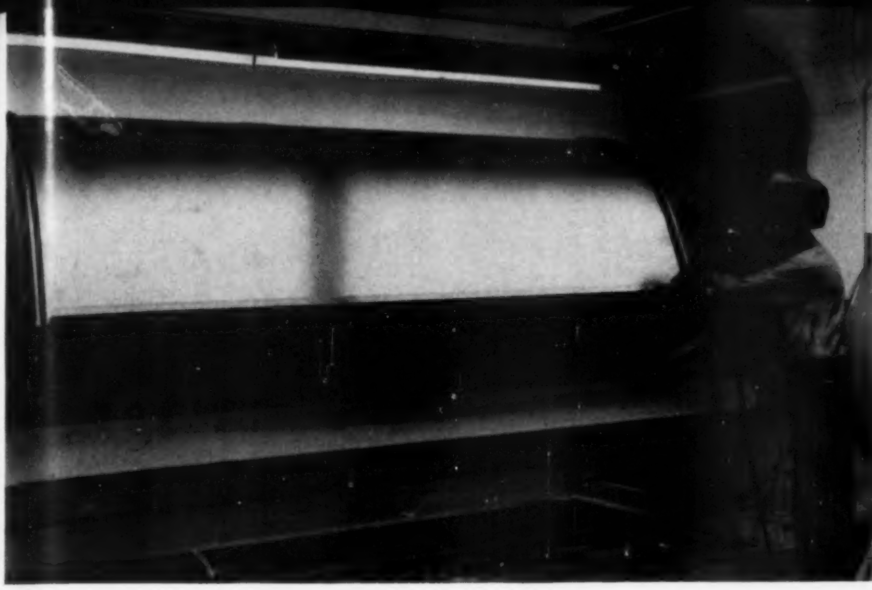
UNITED STATES STEEL

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS



Here's the jig that holds the body sheets while the end sheets are arc welded on.

Frank Ramacier, shop foreman, inspects the finished pasteurizer.

Stainless Steel requires good mechanics, a little care, and good equipment for fabricating

Frank Ramacier, Metal Shop Foreman at the Farwell Metal Fabricating Division of Farwell, Ozman and Kirk Co., St. Paul, has been handling Stainless Steel and other metals for over 20 years. Says he, "If a fellow's a good metal worker, it doesn't take much to teach him how to handle Stainless." He recommends, of course, care in handling and good equipment in good condition.

As an example, let's see exactly how Farwell goes about fabricating a big 500-gallon milk pasteurizer . . .

302 Stainless Steel is used; 18 gage end sheets and 20 gage body sheets.

SHEARING. Paper protection is applied to protect the finish prior to shearing the 49½" x 106" sheets to 49" x 105". A ⅜" capacity shear with blades kept very sharp is used to assure greatest accuracy.

ARC WELDING. Two body sheets are butt welded together to make one body sheet.

NOTCHING. Heavy-duty (60-ton) press is used for top accuracy; notches sheet corners.

FLANGING. Five passes on a 16 gage capacity flanger secure 1" flange on end sheets.

BRAKING. ⅜" capacity brake press is used—again a heavy machine is used to guarantee greater accuracy. Top edge of the end sheets and top edge of the body sheet are flanged to 90°.

ARC WELDING. (second) Welding of the end sheets to body sheet is done on a special jig (see cut) that makes the welding easier and faster. The body sheet is shaped in this jig and is held until the end sheets are welded to it. Top corners are welded together. An outlet is arc welded.

GRINDING. Smoothes and polishes the welds.

That's it and another non-contaminating, corrosion-resistant Stainless Steel pasteurizer is ready to go to work.

Take advantage of Stainless Steel in your designs and in your selling

ere are just a few examples of ow Stainless Steel has been used improve design, add sales ap-al, give better end use results. he wide range of valuable prop-ties available in Stainless Steel akes it the ideal material for any, many jobs.

Put Stainless to work for you. will pay its own way and give u good return on your invest-ent — especially if it is perfected, service-tested USS Stainless Steel.

USS Stainless Steel offers you the widest possible freedom in selecting the grade, shape and finish to fit your design and fabricating procedure best. And the services of our metallurgical engineers are always at your disposal to help you cut costs and get the best results from USS Stainless Steel.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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UNITED STATES STEEL

It's easy to

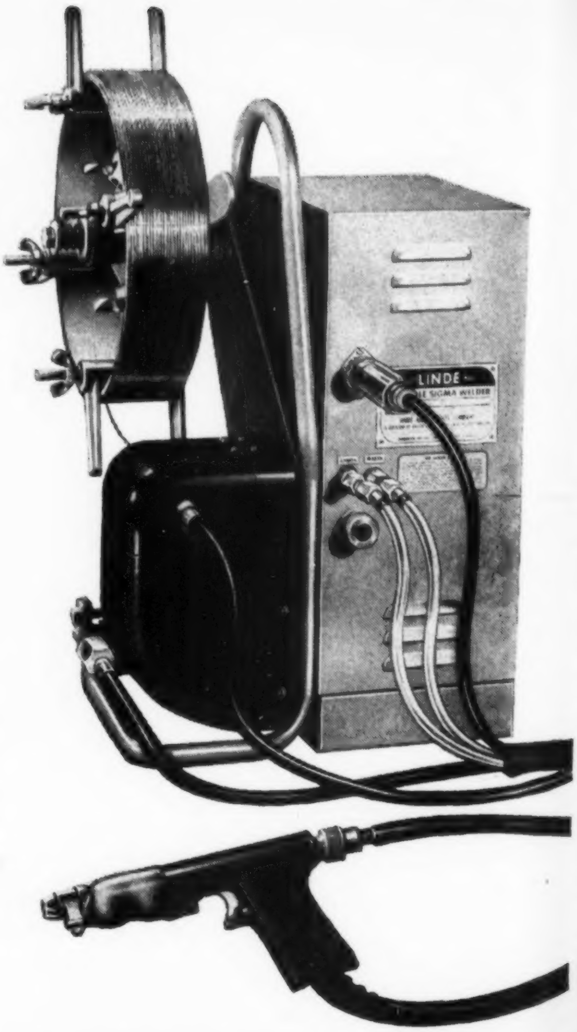
CUT WELDING COSTS

when you use a High-Speed

LINDE SWM-2

Trade-Mark

Portable Sigma Welder



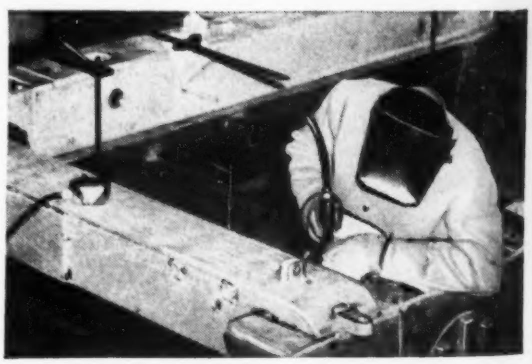
Your welding department can easily make high-speed, low-cost fusion welds in aluminum, stainless steel, high temperature alloys, copper, carbon steel, and other metals with the LINDE SWM-2 Portable Sigma Welder. The LINDE SWM-2 is a complete control unit for manual sigma (Shielded Inert Gas Metal Arc) welding operations. It mechanically feeds welding wire from a coil into the weld area at a steady precontrolled rate and supplies a regulated quantity of argon to shield the weld from contamination by the atmosphere. No flux is used. In most cases the smooth, clean sigma welds need no post-welding treatment.

SIMPLIFIED AUTOMATIC OPERATION

The operator merely presses the trigger of the pistol type torch to energize the control circuit and start the flow of water coolant and argon gas. When an arc is struck by touching the consumable electrode to the workpiece, the wire feed automatically begins.

NEW CONSTANT POTENTIAL POWER SUPPLIES CAN BE USED

Either ordinary or constant potential DC power supplies can be used with a LINDE SWM-2. In constant potential welding arc voltages are preselected and held with outstanding consistency which permits positive starts and high-speed welds on thin metals.



Production jumped 300% when the Heller Engineering and Manufacturing Company, Lynwood, California changed to sigma welding to fabricate aluminum engine shipping stands. Because the sigma welds were clean and sound, post-welding treatment was practically eliminated.

Call your nearest LINDE office today for more information on how you can cut production welding costs with the LINDE SWM-2 Sigma (Shielded Inert Gas Metal Arc) Welder. Or write for your free LINDE SWM-2 catalog.

Linde Air Products Company

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY

Division of Union Carbide Canada Limited, Toronto

Linde

Trade-Mark

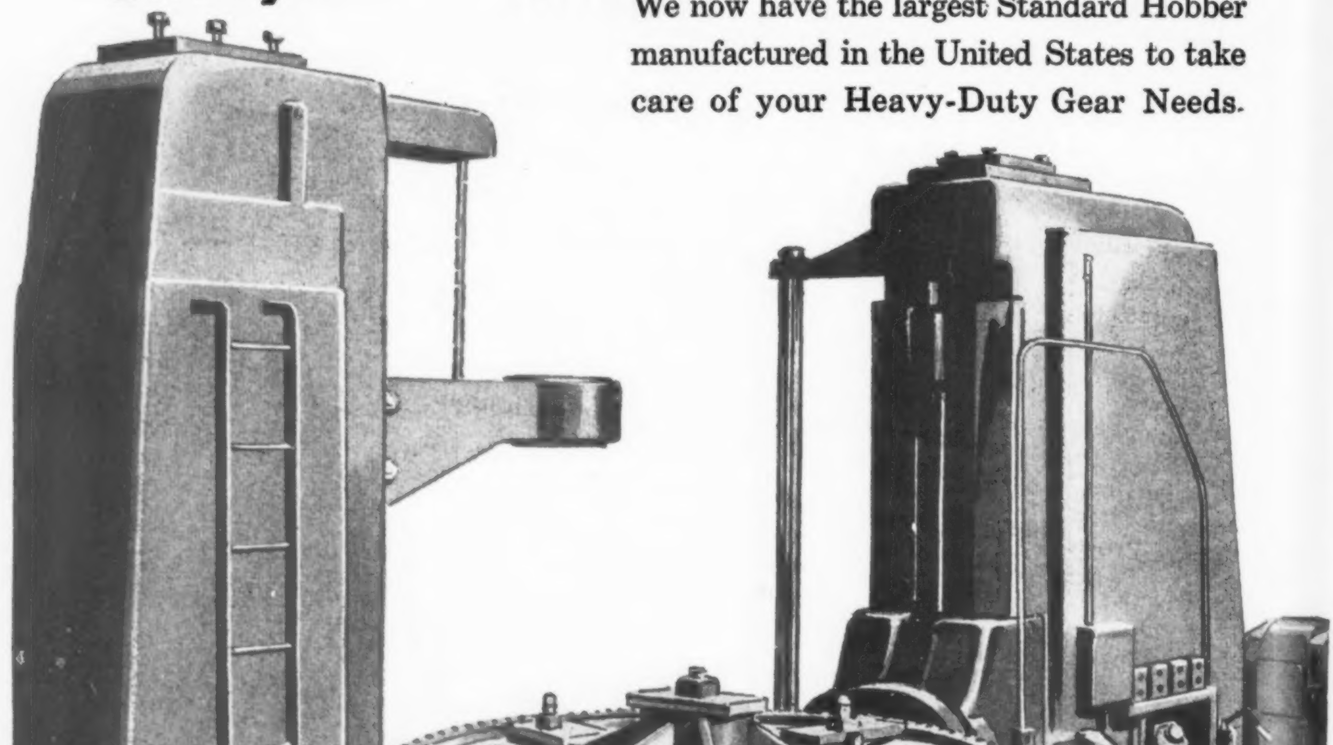
The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.


HYDRAULIC POWER
DELIVERED THROUGH
Eastman
HYDRAULIC HOSE ASSEMBLIES
TILTS 30 TON LOAD 70° IN 21 SECONDS
The Heil "High Angle" Hoist shown here is capable of elevating a 30-ton rock load 70° in 21 seconds . . . cutting overhead, time and operating costs by quick, clean unloading in "round-the-clock," quarry operation.
Heil Truck Bodies and Hoists, known for their quality, durability and sound engineering—are likewise equipped with *quality* Hydraulic Hose Assemblies—by EASTMAN of Manitowoc, Wis.—first in the field of modern hydraulic power application.
Protect the performance of *your* product by relying on the high standards of quality and workmanship in EASTMAN Hydraulic Hose Assemblies. Safeguard *YOUR* Lifelines of Mobile Power, too!
SAFEGUARDING INDUSTRY'S Lifelines of Mobile Power
WRITE for our Catalog 101 on Eastman Hydraulic Hose Assemblies
e tremendous lifting power of the Heil Hoist is ained through twin cylinders and extremely werful linkage—with only 1000 psi delivered ough Eastman Hydraulic Hose Assemblies.
Eastman
first in-the-field
MANUFACTURING COMPANY
Dept.MD12, Manitowoc, Wis.
Anthony Lift Gate
Anthony Lift Gate, built by pioneer company in truck lifts—equipped by Eastman, pioneer in hydraulic hose assemblies. Up to 4000 lbs. lift.
Drott Skid Shovel
Drott Skid Shovel, built for International, equipped with Eastman Hydraulic Hose Assemblies. Lift capacity —4000 lbs. Breakout force—11,500 lbs.

Industrial Gear

always a step ahead with the latest

We now have the largest Standard Hobber manufactured in the United States to take care of your Heavy-Duty Gear Needs.



IN STOCK

A full range of Hobs to produce the tip relieved tooth form necessary to prevent interference under heavy load.

Industrial Gear Mfg. Co.

4529 W. VAN BUREN ST.
CHICAGO 24, ILLINOIS

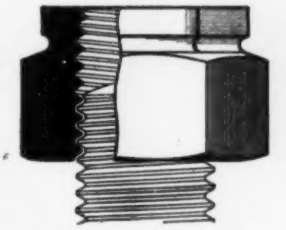
This portable electric hammer is completely self-contained. So are the one-piece, all-metal FLEXLOCs that hold it together, even under the intense impact vibration induced by the rapid hammering action.

FLEXLOCS chosen to withstand vibration of 3000 hammer blows per minute

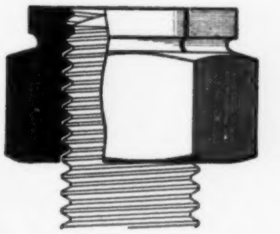
The manufacturer of this portable electric hammer reports, "FLEXLOC Self-Locking Nuts have solved our problem of obtaining a desirable fastener, because they withstand the terrific vibration induced by the impact of 3000 hammer blows per minute without working loose."

This portable electric hammer is subjected to terrific impact-induced vibration. The fasteners that hold it together must take the same beating. The FLEXLOCS were selected only after numerous fastening devices had been tested. Two ¼″-20 nuts hold the fastening bolts securely in position on the forward end of the hammer. One 1″-14 nut prevents loosening of the components at the nose.

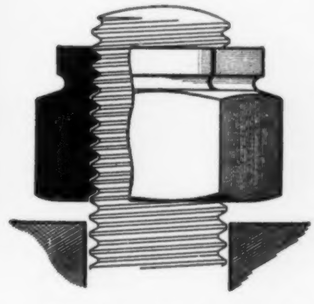
You can get FLEXLOCS of various types and materials in a wide range of sizes and in any quantity. And these one-piece, all-metal locknuts are carried in stock by leading industrial distributors everywhere. See your FLEXLOC distributor or send for literature and samples. STANDARD PRESSED STEEL CO., Jenkintown 18, Penna.



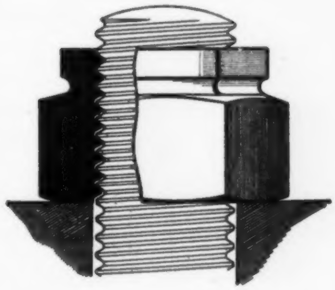
Starting. A FLEXLOC starts like any ordinary nut. Put it on with your fingers. Tighten it with a standard hand or speed wrench.



Beginning to Lock. As the bolt enters the segmented locking section, the section is expanded, and the nut starts to lock.



Fully Locked As a Stop Nut. When 1½ threads of a standard bolt are past the top of the nut, the FLEXLOC is fully locked. A FLEXLOC does not have to seat to lock.



Fully Locked As a Seated Nut. When it is used as a lock or stop nut, the locking threads of the FLEXLOC press inward against the bolt, lifting the nut upward and causing the remaining threads to bear against the lower surface of the bolt threads. Vibration will not loosen a FLEXLOC, yet there is no galling of threads.

FLEXLOC® LOCKNUT DIVISION

SPS JENKINTOWN PENNSYLVANIA

Why Minnesota Rubber parts are more dependable

Dependability is a result of high standards. Minnesota Rubber's rigid quality controls and exclusive injection molding process maintain critical tolerances with consistently homogeneous rubber formulation. Injection molding securely bonds rubber to brass, steel, other metals—and simplifies production of parts with intricate sizes and shapes. Cost? Lower than the industry average!

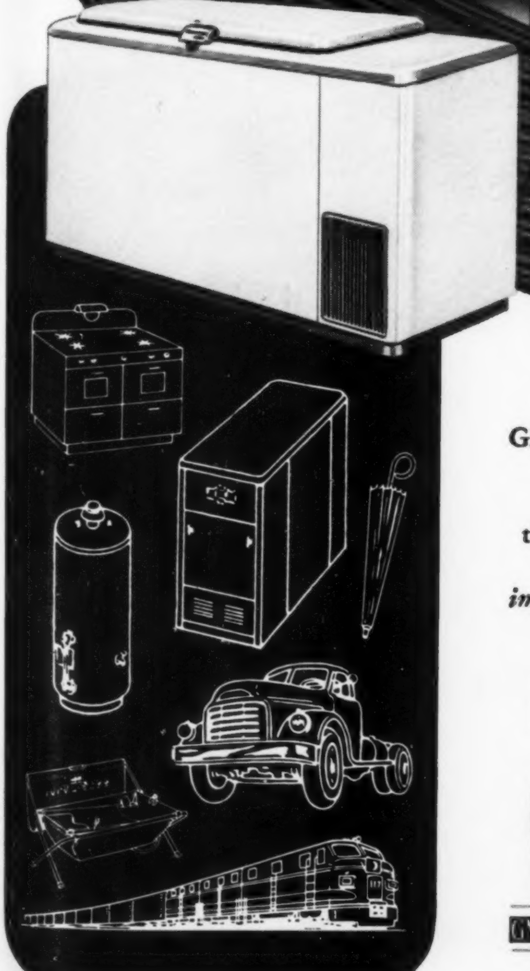
One of the best proofs of superiority is success. Hundreds of successful applications and satisfied customers prove that Minnesota Rubber parts are more dependable. All O-rings and custom molded parts are inspected to sustain the level of success and customer satisfaction that has made Minnesota Rubber famous. Don't let a rubber parts problem throw your production out of step . . . call Minnesota Rubber on stage for the best answer at the lowest possible cost. Write today for details. For complete O-ring installation data, request the new free catalog 9-B, "O-rings."

Minnesota Rubber and Gasket Company

3630 Wooddale Ave., Minneapolis 16, Minnesota

Dept. 308, Phone MOhawk 9-6781

The Tube Line That Rates a Buy-Line!



IN THE DESIGN and building of the products shown here, GM Steel Tubing plays an important part—either for the passage of liquids or gases, or as part of the mechanical structure. And these are but a few of the thousands of manufactured items that use low-cost steel tubing in place of more expensive materials. Examine your own requirements! You, too, may find you can *improve design, speed production,* and *cut costs* with "The Tube Line That Rates a Buy-Line"—GM Steel Tubing!

SEE SWEET'S PRODUCT DESIGN FILE $\frac{\text{Ia}}{\text{Ro}}$

SEND FOR FREE **BROCHURE**

This new, illustrated, fact-packed brochure tells how GM Steel Tubing can help solve design and production problems. Send today for your free copy.

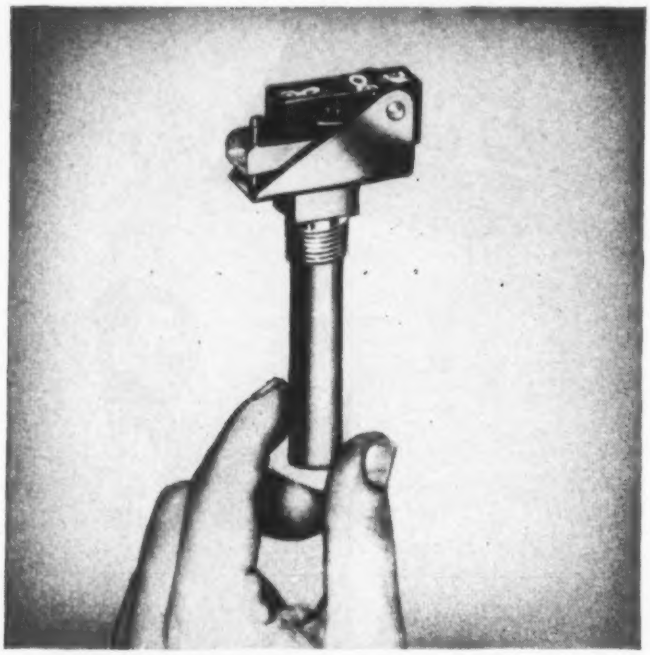
GM STEEL TUBING

ROCHESTER PRODUCTS

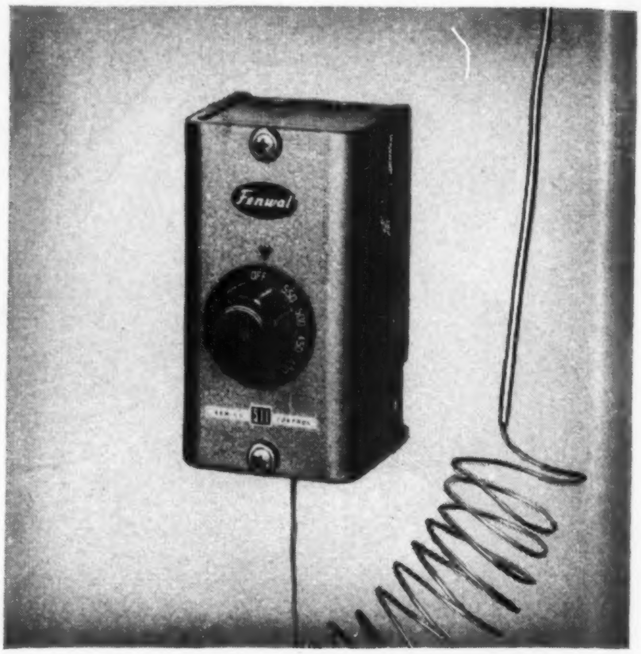
DIVISION OF GENERAL MOTORS, Rochester, N. Y., U.S.A.

ALSO MANUFACTURERS OF ROCHESTER CARBURETORS AND ROCHESTER CIGAR LIGHTERS

Heard about Fenwal's two new snap-action THERMOSWITCH® units?



1. FOR LOCAL CONTROL. Series 20,000, local bulb type, is an important advance over conventional bellows-actuated temperature controls. Bellows arrangement in the liquid-filled bulb permits sensitivity over virtually the entire area of the shell, greatly reducing lag. Temperature range: 50° to 300°F. Load rating: 20 amps at 120V AC.



2. FOR REMOTE CONTROL. Series 511, remote bulb type, includes a long capillary tube connecting the probe at the point of temperature change. Like the Series 20,000, it provides the advantages of maximum sensitivity and instant actuation of the snap-switch. Temperature ranges: 60° to 250°F, or 200° to 550°F. Load ratings: 25 amps at 250V AC; 35 amps at 125V AC.

3. FENWAL DEPENDABILITY IN BOTH. These bellows-type snap-action THERMOSWITCH units are typical products of Fenwal research, featuring sensitivity, stability and quick, positive action. Precision-built for uniformity, ruggedness and dependability, they are valuable additions to the expertly engineered, widely useful THERMOSWITCH line.

4. SEND FOR DATA BULLETINS. Get complete facts on the new Fenwal snap-action THERMOSWITCH devices, now. We'll be glad to send you comprehensive bulletins on either or both types, or to discuss any problem involving temperature control or detection. **Write Fenwal Incorporated, 1912 Pleasant St., Ashland, Mass.**

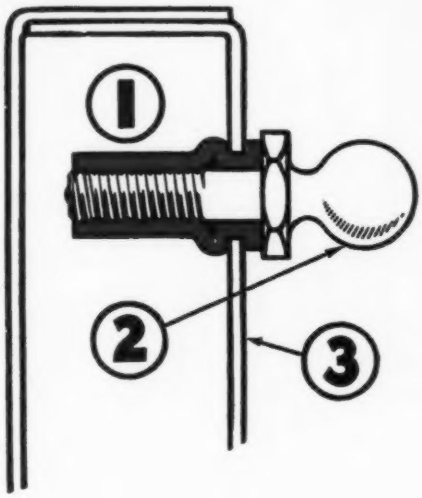
Fenwal

THERMOSWITCH®

Electric Temperature Control and Detection Devices

SENSITIVE...*but only to heat*

One B. F. Goodrich RIVNUT solves 3 fastening problems!

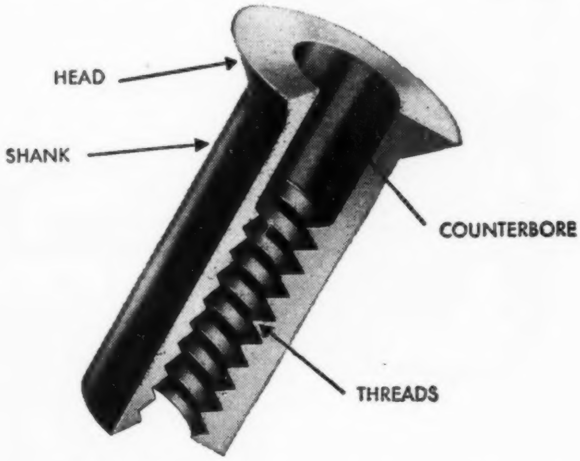


A RIVET WAS NEEDED for doors of metal cabinets that 1) could be installed from one side only, 2) would serve as a nut plate for a knob attachment, and 3) could be installed after enameling. A B. F. Goodrich Rivnut proved the perfect answer.

A flat-head Rivnut is inserted in the sheet metal door. Working from one side, one man can upset Rivnut in 2 seconds with easy-to-operate heading tool. Bulge formed in Rivnut shank grips the metal tightly. The knob of the catch is then threaded into the clean, still-intact Rivnut threads. Rivnuts are installed after enameling without marring the finish.

This simple solution saved many man-hours on the job. If you have a fastening problem, why not put it up to Rivnut engineers? Write to The B. F. Goodrich Company, Dept.MD124, Akron, Ohio.

THIS IS A B. F. GOODRICH RIVNUT . . . . THIS IS HOW IT WORKS

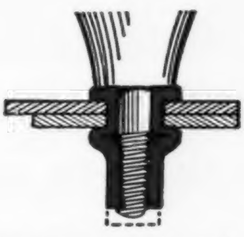


This cross-section shows the threads by which the Rivnut is threaded onto the pull-up stud of the heading tool. These threads are not injured by the heading operation and enable you to fasten *to* a Rivnut as well as *with* it.

The Rivnut provides a large bearing surface, requires only a small hole, and can be installed after enameling without marring the finish.

1. Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.

2. Rivnut is inserted, head firmly against work, tool at right angles to work.



3. Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4. After upset, threads are still clean and intact, ready for screw attachment.

B.F. Goodrich

RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Shows with motion how Rivnuts work. Explains construction, gives proved applications. Write to The B. F. Goodrich Co., Dept.MD124, Akron, Ohio.

PERHAPS YOUR TIMER WILL BE THE 661st

How do you know we can supply you with the timer that will do your job best? Because we have 19 years of experience in developing new timers to meet our customers widely varied requirements. If one of our standard timers won't do it—or one of the 660 combinations we have thus far developed from our 17 basic units—our engineers will develop the 661st combination, for your specific needs.

We manufacture a complete line of timers in these 4 broad classifications:

TIME DELAY TIMERS • INTERVAL TIMERS
RE-CYCLING TIMERS • RUNNING TIME METERS

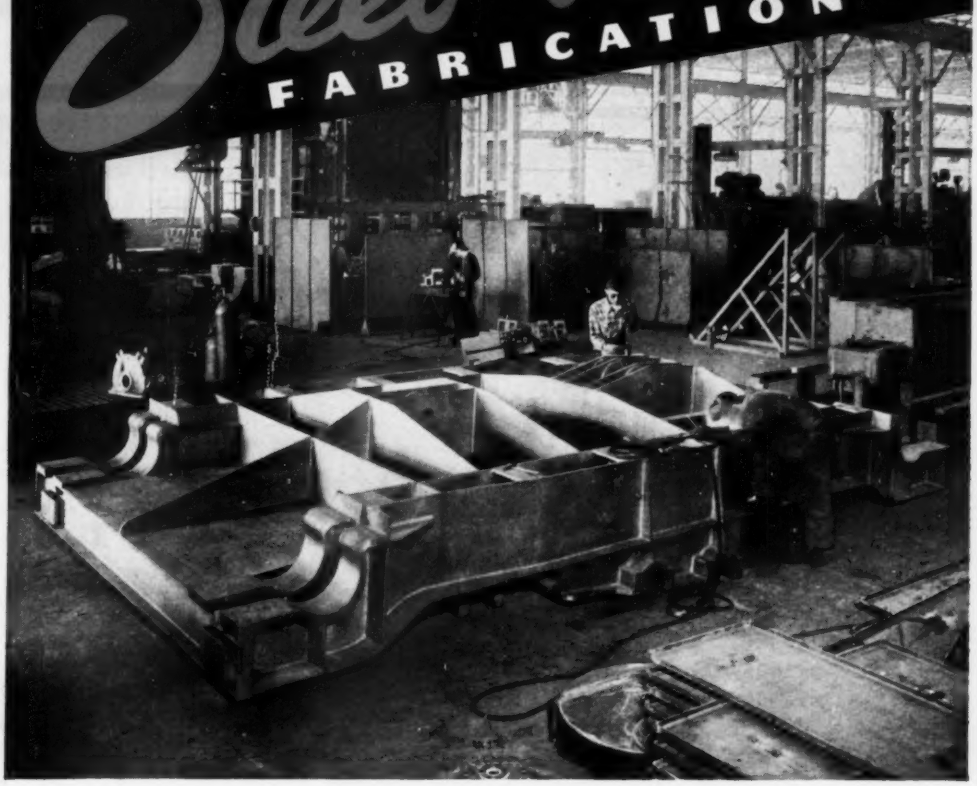
And since we maintain large stocks of our 17 basic units, we can assure you of rapid deliveries—and of good deliveries even on special orders. Automation? We're in it up to our ears...just put your problem up to one of our timer specialists. Your inquiries will receive prompt attention.

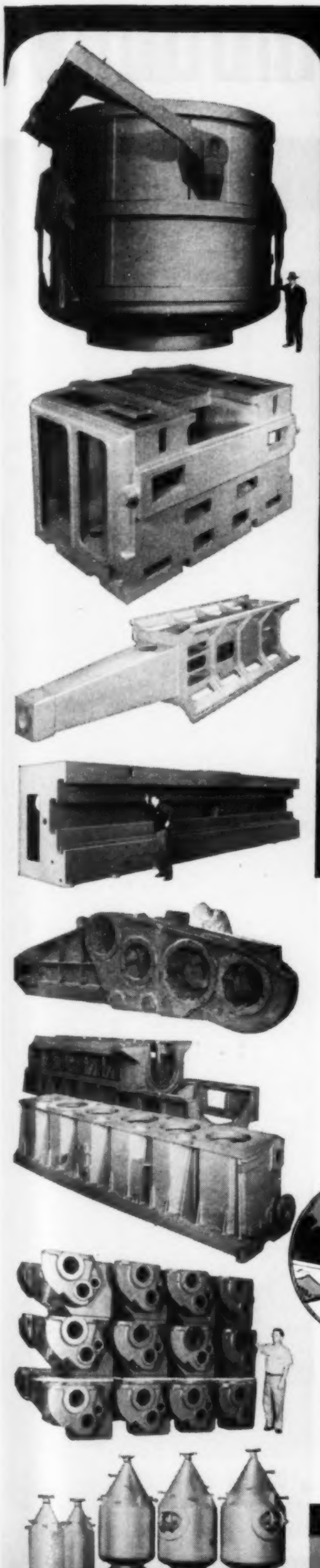
Timers that Control - the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION
131 OGDEN STREET, NEWARK 4, N. J.

Steel-Weld FABRICATION





Use WELDED STEEL for Greater Strength with Less Weight!

Heavy Steel-Weld Fabricated parts like the piece illustrated above, and the parts and assemblies shown at the left, are typical examples of work produced by Mahon for hundreds of manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. If you need a complete special mechanical device or piece of equipment, or if you require parts or assemblies involving large heavy pieces where time and pattern costs are a consideration, you can turn to Mahon with complete confidence . . . personnel and facilities are available within the Mahon plant to do the complete job from drawing board to finished machining and assembly. You will find in the Mahon organization a unique source with ultramodern fabricating, machining and handling facilities to cope with any type of work regardless of size or weight . . . a source where design skill and advanced fabricating technique are supplemented by craftsmanship which assures a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Mahon's Insert in Sweet's Product Design File, or have a Mahon engineer give you complete information.

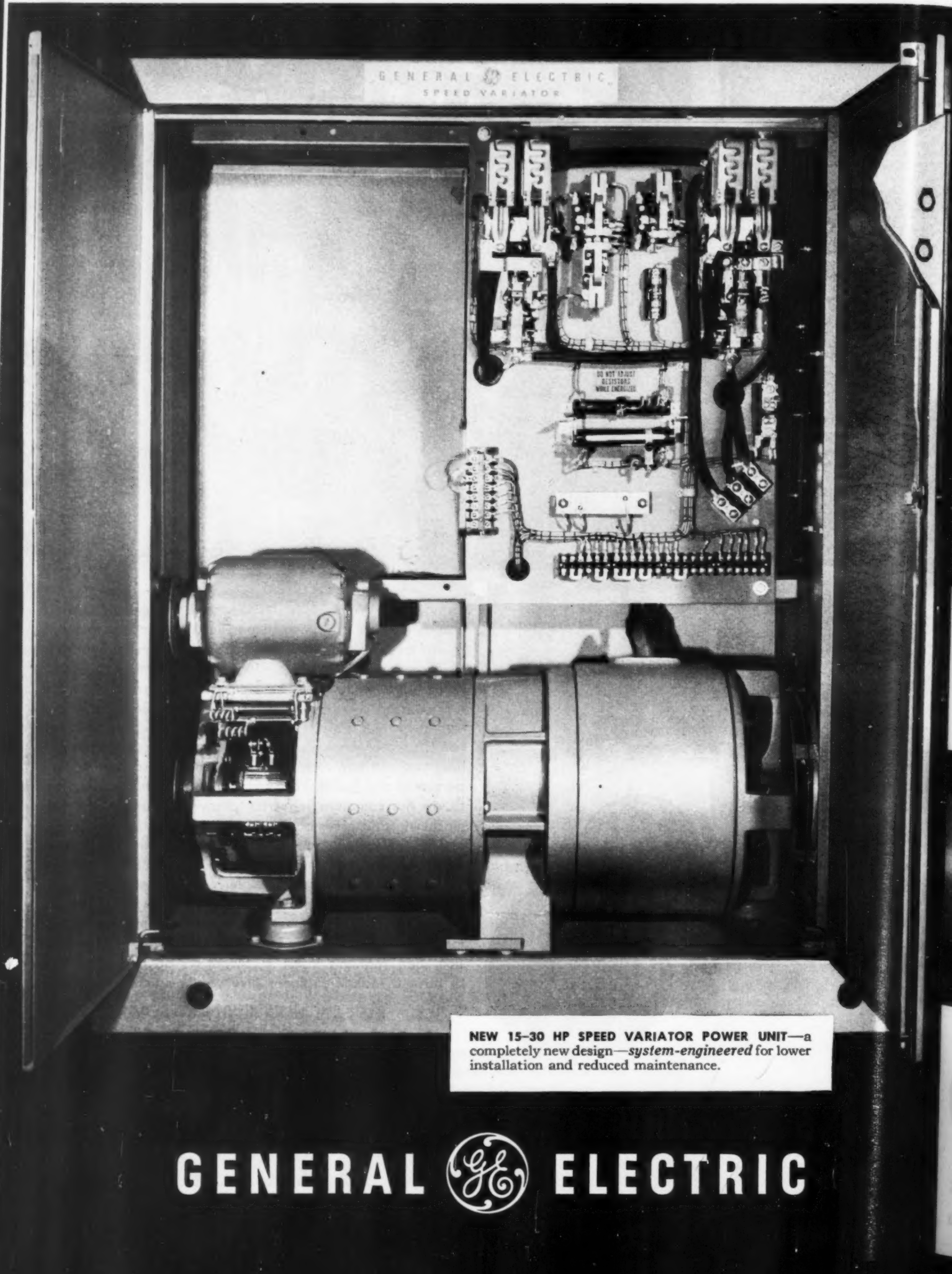
THE R. C. MAHON COMPANY

DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

General Electric Announces



NEW 15–30 HP SPEED VARIATOR POWER UNIT—a completely new design—***system-engineered*** for lower installation and reduced maintenance.

GENERAL ELECTRIC

NEW 15-30 hp Speed Variator

Gives you lower installation and maintenance costs— PLUS better adjustable-speed performance.

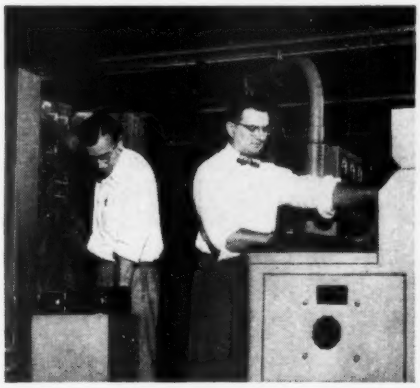
COMPLETELY REDESIGNED, this 15–30 hp power unit is the latest addition to the General Electric Speed Variator line—a packaged, adjustable speed drive—*system engineered* to improve and simplify your machine operation.

NEW FEATURES, designed and engineered to give you lower installation and maintenance costs and more accurate, versatile adjustable-speed performance, are illustrated below.

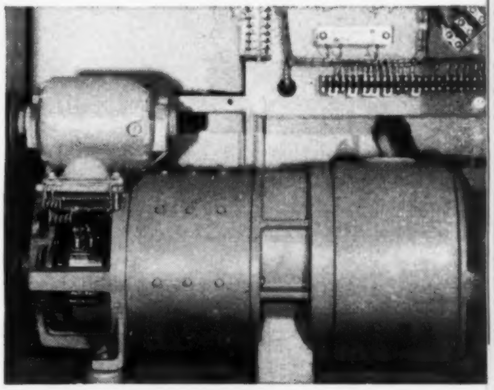
FOR MORE INFORMATION, write Section 822-2 for bulletin GEA-6180 on the 15–30 hp unit, bulletin GEA-6127 on the complete 1 to 200 hp line, or contact your nearest G-E Apparatus Sales Office. General Electric Co., Schenectady 5, N. Y. 822-2

LOWER INSTALLATION COSTS

NO SPECIAL FOUNDATION NEEDED for power unit—no bolting down—just a reasonably level space. Fewer conduits to run between components—power unit and operator's control station can be located wherever convenient.

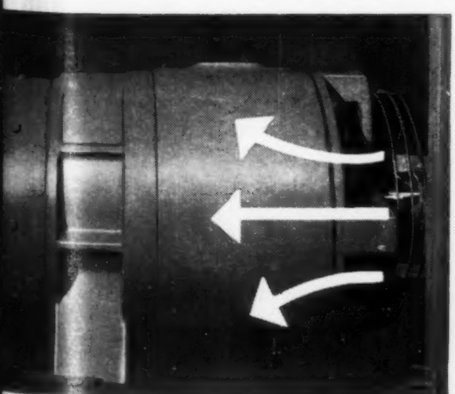


COSTLY SET-UP TIME REDUCED—Every Speed Variator is completely tested and all major adjustments made at the G-E factory. You receive a packaged drive, *system-engineered* for you, ready to install and operate.

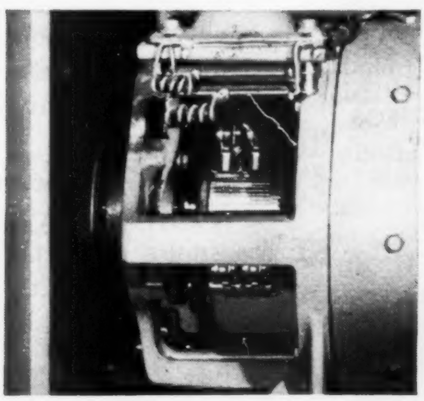


NO M-G SET ALIGNMENT PROBLEMS—All motor generators are factory installed, wired and tested. Set is mounted in cabinet on self-supporting base—three-point suspension on rubber dampers reduces vibration and noise.

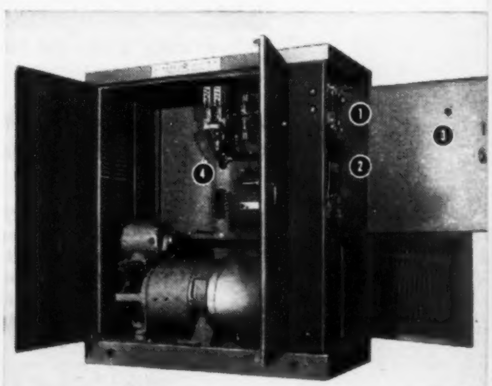
BETTER PROTECTED—LESS MAINTENANCE



POSITIVE PRESSURIZED CABINET assures cleaner operating atmosphere for power unit—large fan pulls air through glass fiber filter, raising inside pressure. Air filters are inexpensive, easily replaced. Removable doors, front and back.

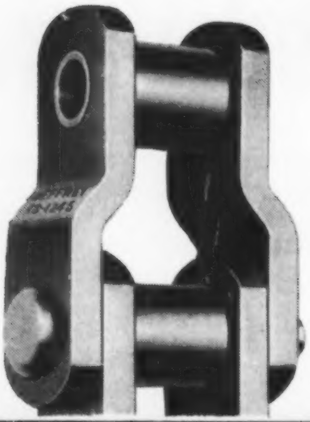


SIMPLIFIED MAINTENANCE—Large handholes and cutback cabinet provide easy access to brushes, commutator and grease fittings. Standard control throughout with color-coded wiring for easy identification and quick maintenance.



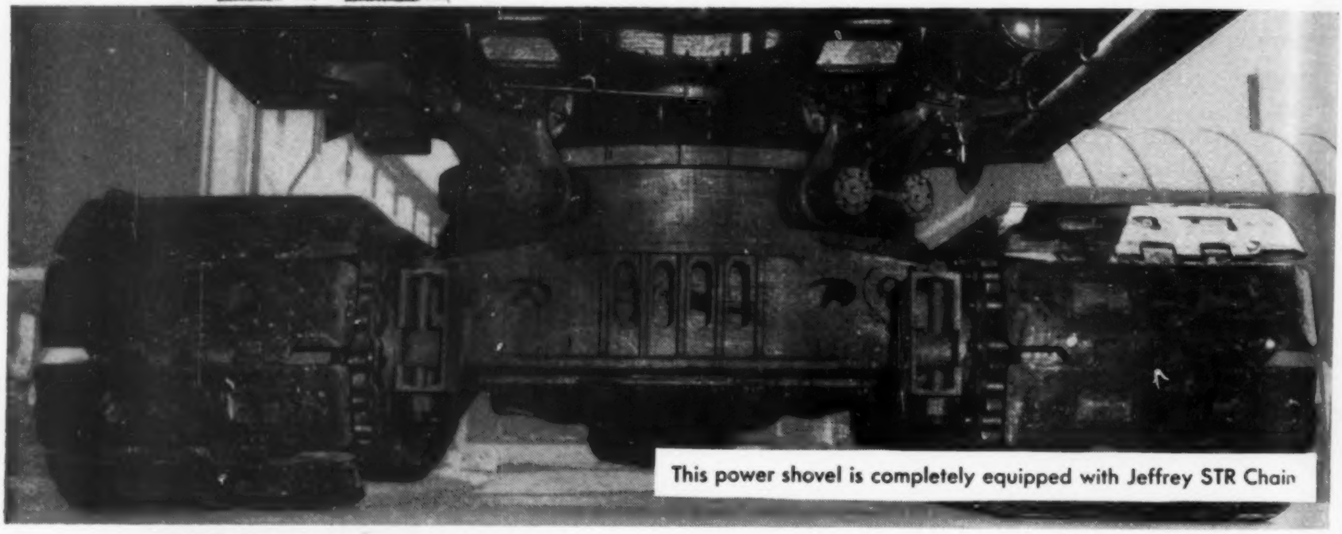
BETTER PROTECTED EQUIPMENT—(1) A-c control is in separate compartment. (2) Short-circuit protection inside case. (3) Lockable disconnect switch must be OFF to open a-c door. (4) D-c devices equipped with d-c control for longer life.

GENERAL ELECTRIC



Engineers' choice:

JEFFREY drive chain quality makes good equipment better



This power shovel is completely equipped with Jeffrey STR Chain

Heavy duty concrete mixer uses Jeffrey STR Chain.

JEFFREY COMPONENTS FOR ORIGINAL EQUIPMENT:

- STR DRIVE CHAINS
- STEEL CARVE SPROCKETS
- HOLLOW PIN CHAINS
- CAST IRON SPROCKETS
- STEEL KNUCKLE CHAINS
- BABBITTED PILLOW BLOCKS
- COMBINATION CHAINS
- SPIRAL CONVEYORS

Equipment manufacturers from coast to coast rely on Jeffrey STR chain for flexible transmission of power in large and small unit machines such as power shovels, draglines, road pavers, ditchers, concrete mixers, garbage trucks, dredges and portable loading machines.

STR chain, in pitches of 1½" to 7", is ideal for drives on conveyors, elevators, machine tools, etc. Longer pitches, combined with attachments, are adapted to heavy duty elevating and conveying service.

If your equipment can use the superb quality of Jeffrey STR Drive Chain and Sprockets—you'll find they offer maximum strength for minimum weight, with ample reserve strength to permit normal wear and to withstand unexpected overloads.

THE JEFFREY MANUFACTURING CO.

ESTABLISHED 1877

Columbus 16, Ohio

sales offices and distributors in principal cities

PLANTS IN CANADA, ENGLAND, SOUTH AFRICA

IF IT'S MINED, PROCESSED OR MOVED . . . IT'S A JOB FOR JEFFREY!

This hole means savings —instead of shavings

THE hole in the tube above should have been packed full of money. It would have been a quick way to show you some of the money you'll save when you switch to Timken® seamless steel tubing for your hollow parts jobs.

Because the hole's already there, you eliminate practically all of the scrap you have to drill out when you use bar stock—the steel you pay for but don't use.

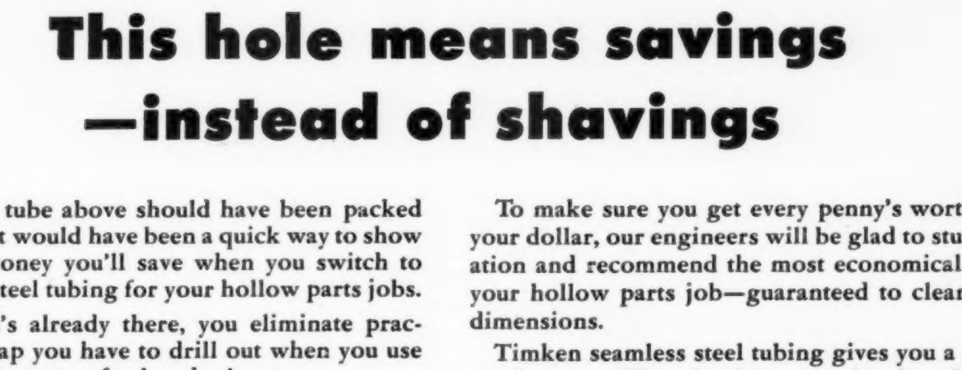
Because the hole's already there, you can start with finish boring. You can make your hollow parts faster, with less equipment and fewer production steps.

Because the hole's already there, screw machine stations and men are available for other operations. You add machine capacity without adding machines. You use your employees more efficiently.

To make sure you get every penny's worth of steel for your dollar, our engineers will be glad to study your operation and recommend the most economical tube size for your hollow parts job—guaranteed to clean up to finish dimensions.

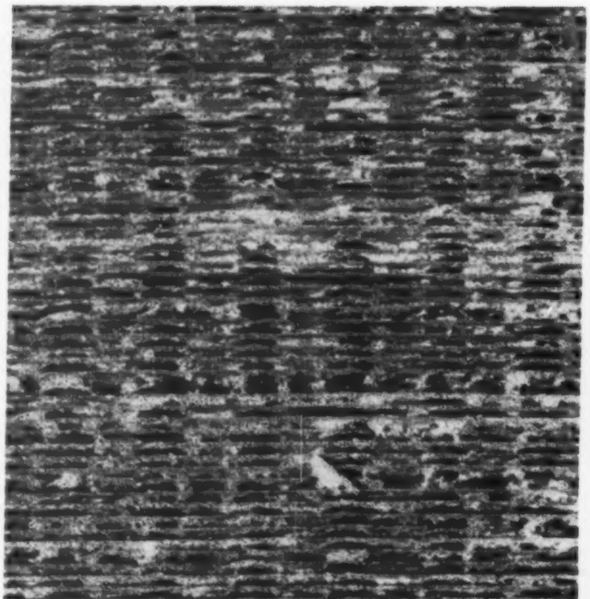
Timken seamless steel tubing gives you a better quality product, too. The piercing operation by which it's made is basically a forging operation. This gives the tubing a uniform spiral grain flow and a refined grain structure that brings out the best in the quality of the metal. And this quality is uniform from tube to tube and heat to heat because of the Timken Company's rigid quality control. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

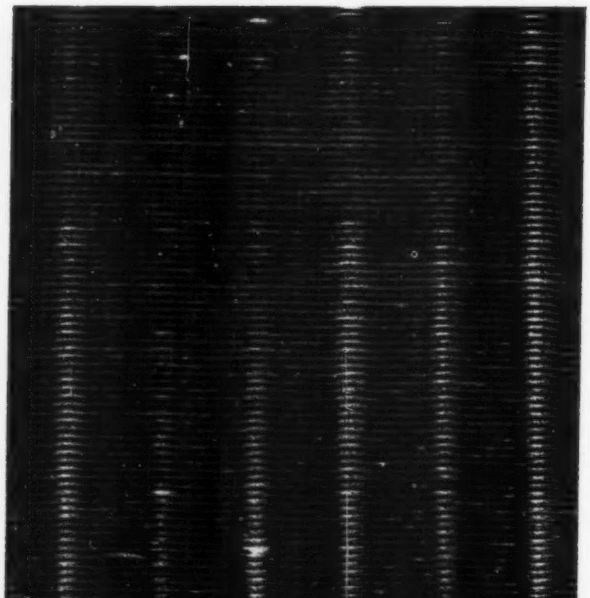


SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

1150-hour salt spray test shows increased corrosion resistance with Bonderite on aluminum



UNTREATED. *Unretouched photo of section of aluminum refrigeration air conditioner condenser after 1150 hours in salt spray. Note corrosion.*



BONDERITE-TREATED. *Unretouched photo of identical aluminum refrigeration air conditioner condenser after 1150 hours in salt spray. Note absence of corrosion.*

If you want more effective bare corrosion resistance or increased durability for paint, treat aluminum and its alloys with Bonderite.

Special formula Bonderites have been developed and tested and proven thoroughly for this purpose. They form a thin, irridescent, remarkably effective integral coating with the aluminum in simple and economical operation. Solutions are sludgeless, easily controlled, and produce results of uniform high quality.

The Bonderite coating is flexible, withstanding moderate draws without trouble. The coating conducts electricity, necessitating no change in arc and spot welding procedures. Bimetallic and galvanic corrosion resistance is high.

Bonderite for aluminum is shipped in concentrated liquid form, easy and safe to handle and use.

Get complete information on this more effective protection for aluminum and its alloys. Write for bulletin on Bonderite 710 and 720.

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

Since 1915—Leader in the Field

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

PARKER RUST PROOF COMPANY
2193 E. Milwaukee, Detroit 11, Michigan

BONDERITE corrosion resistant paint base
BONDERITE and BONDERLUBE aids in cold forming of metals
PARCO COMPOUND rust resistant
PARCO LUBRITE wear resistant for friction surfaces
TROPICAL heavy duty maintenance paints since 1883

DELCO MOTORS

the best running mate <u>your</u> product can have

In this pushbutton age, millions of Delco motors supply the actuating power to operate the appliances, tools and equipment that help to create our American standard of living.

This widespread use of Delco motors is convincing testimony to their outstanding, dependable performance. Popular endorsement on such a broad scale suggests that a Delco motor is the best running mate *your* product can have.

DELCO PRODUCTS
DIVISION OF GENERAL MOTORS CORPORATION
DAYTON 1, OHIO

SALES OFFICES:
Atlanta • Chicago • Cincinnati • Cleveland • Dallas
Detroit • Evansville • Hartford • Kansas City • Los Angeles
Philadelphia • St. Louis • San Francisco • Syracuse

HEIM *Unibal* ROD ENDS

contribute to cutting costs through plant modernization.

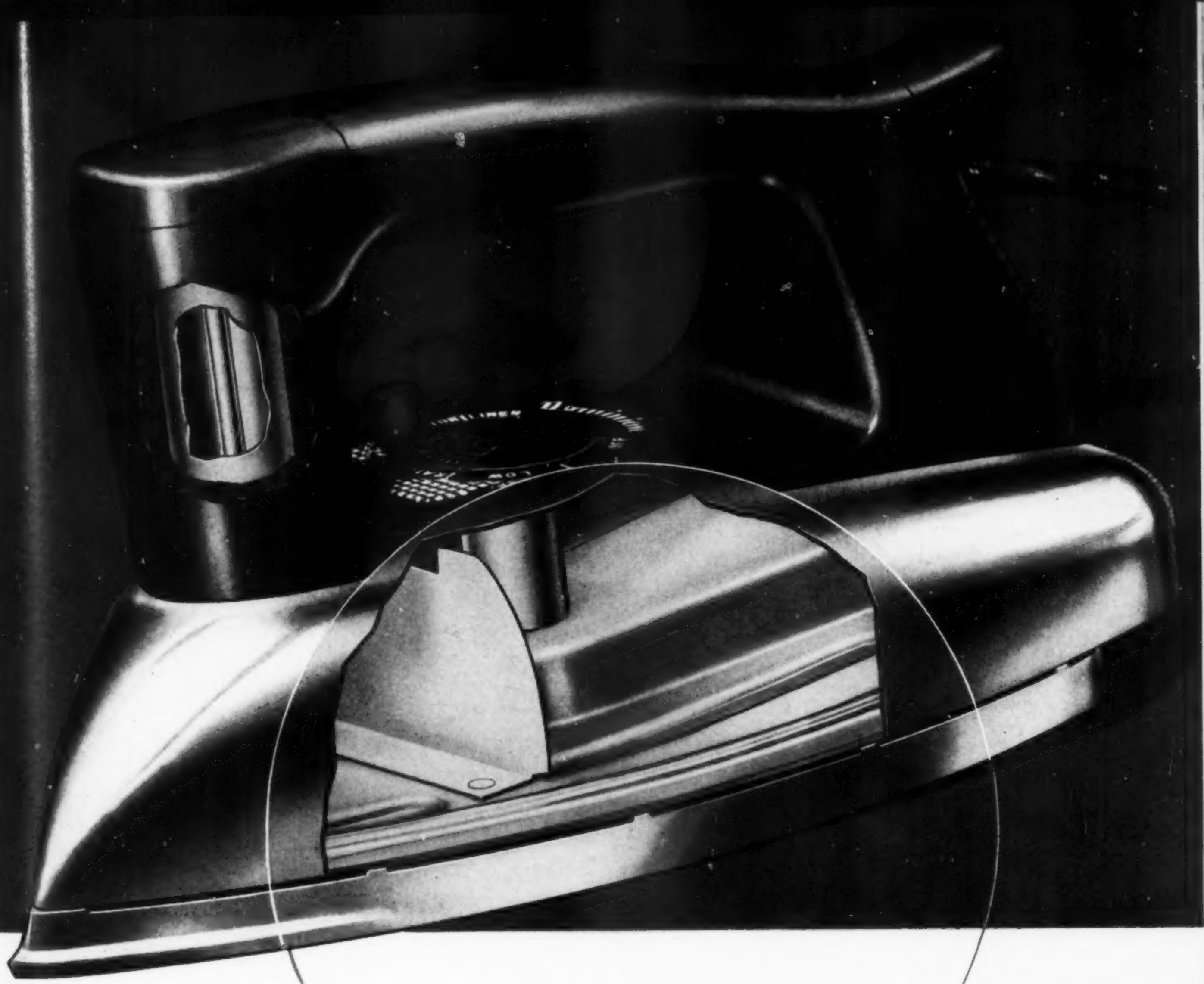
A dramatic feature of the modernization of the nation's packing plants has been the emphasis on speed as a means of minimizing production costs. The 30-pocket rotary filler for handling liquid or semi-liquid materials, made by the Sprague-Sells division of Food Machinery and Chemical Corporation, as an example of increased speeds, will turn out 650 five-ounce jars per minute. The downward stroke of the piston draws the product into the cylinder, the upstroke forces the material into the container. A closer look at this FMC filler shows a HEIM Unibal Rod End at each of the thirty stations, correcting misalignment where necessary and contributing toward the close accuracy of fill obtained by this machine.

HEIM Unibal Rod Ends consist of a single ball through which the shaft or stud passes, bronze bearing inserts pressed around the ball, and a housing of steel or other specified materials. They correct misalignment in every direction, they reduce friction and lost motion in mechanical linkages, and they cost less than specially machined rod ends.

What is your Linkage problem

Perhaps HEIM
can help solve it
. . . or simplify it.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT



Peek under this gleaming chromium plate

and see functional, durable, BRASS at work

In adding a combination steam-and-dry iron to its list of electrical appliances, The Dominion Electric Corp., Mansfield, Ohio, set its goals high. The iron had to be engineered, styled and priced so as to be readily salable in a highly competitive market.

1 Costs *must* be kept down — without sacrificing quality.

2 The iron *must* be light in weight (actually 3¼ lb.) and provide a long service life.

3 It *must* operate unfailingly — anywhere — on ordinary, undistilled tap water.

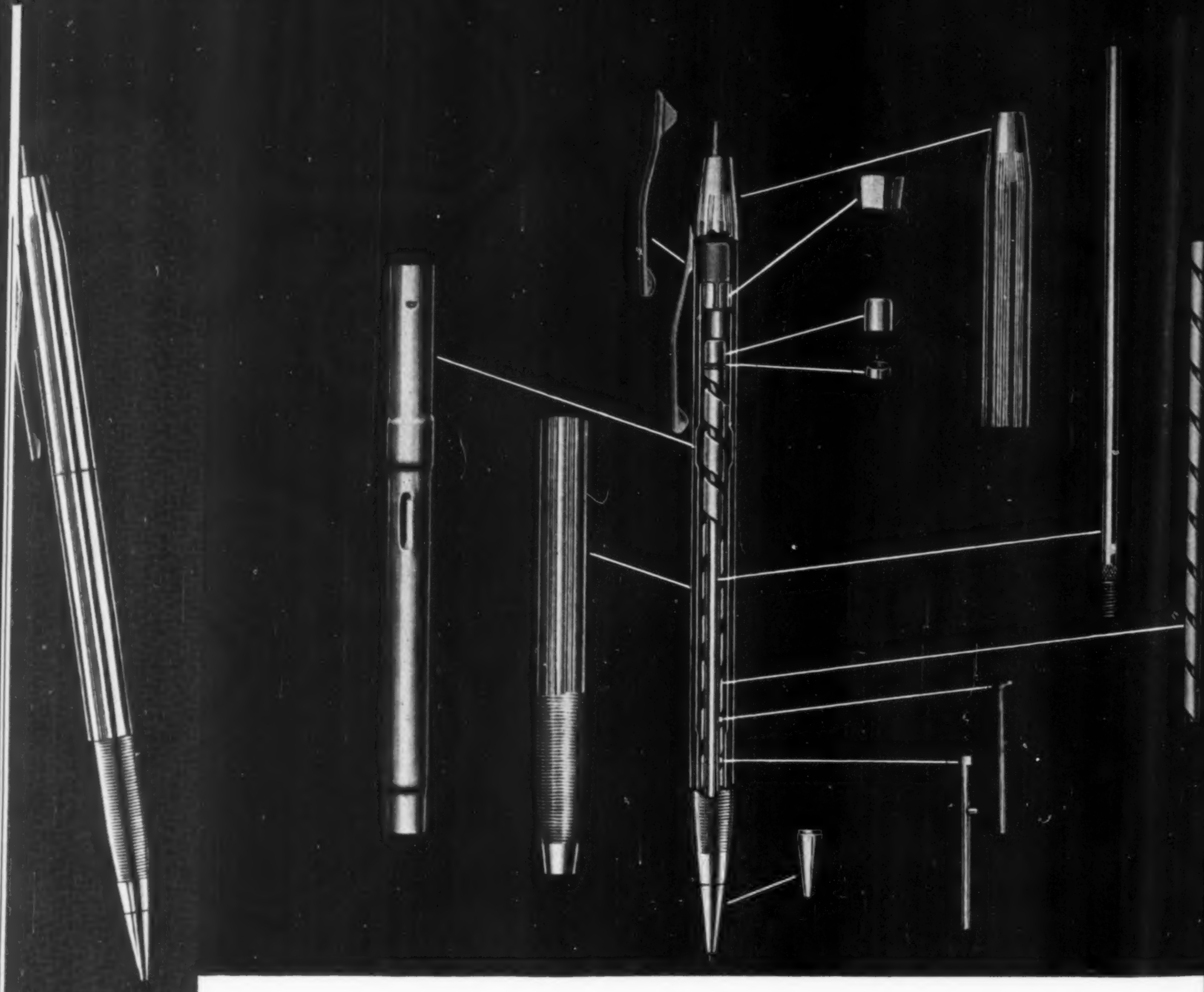
For the housing, steam generator, filler tube and miscellaneous supporting members, BRASS was the answer — as it so often is where freedom from rust, resistance to corrosion, workability and ease-of-finishing must be coupled with moderate cost.

We are glad to report that Dominion's choice and extensive use of Anaconda Brass paid off handsomely; also that we were able to give their engineering and production staffs an assist in selecting the right compositions and the most economical gages and tempers. Perhaps we can do the same for you? Simply write The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 5489

ANACONDA

the name to remember in

COPPER • BRASS • BRONZE



CROSS put an end to automatic pencil troubles **with BRASS**

Since 'way back in 1846, America's oldest manufacturer of fine writing instruments—the A. T. Cross Pencil Company, Providence, R. I.—found out that you can do things with brass that you can't do with any other metal. And they've been doing it ever since.

Illustrated above in actual size are an even dozen parts that make up the chromium plated Cross Pencil. All, except the spring clip of phosphor bronze, are made of brass supplied as sheet, strip, wire, rod or tube.

Note the multiplicity of fabricating operations—from the free cutting brass point to the strip-wound spiral—and you'll come to the conclusion that brass gives you the most "easy workability" for your money.

And the man who owns a Cross Pencil—or Pen—is far less apt to fume or fuss. He's got a writing instrument that's tops in quality at a moderate price, with parts that resist wear and corrosion . . . that won't rust, gall or "freeze."

Dependable brass is plentiful—and unrestricted. The days of substitutes are over. Next time the man at the drawing board looks up and says "What'll it be," say "Make it brass." Better yet, say "Anaconda Brass." The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

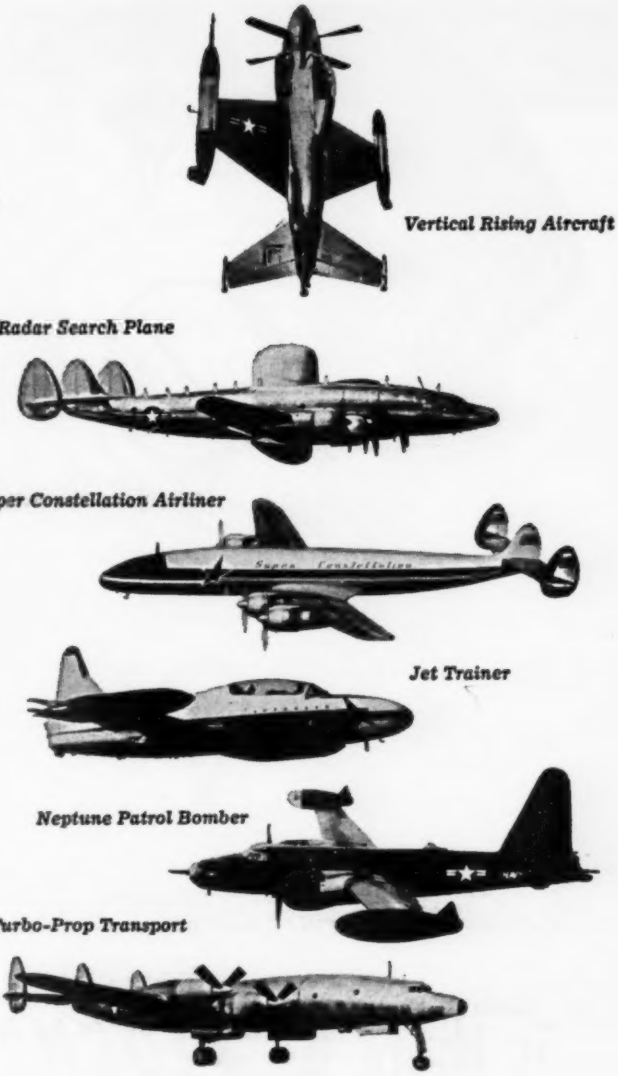
In the exploded view, above, is featured the pencil of the A. T. Cross Chromium Plated Pen and Pencil Set. All parts, including those in the pen, are made of Anaconda Alloys supplied by The American Brass Company since 1913. Cross also uses the same "inside working parts" in two "Century" Pen and Pencil Sets in which the caps, barrels and clips are available in either sterling silver or 1/20 12K gold-filled (illustrated above).

ANACONDA

the name to remember in

COPPER • BRASS • BRONZE

Result of diversification:



Lockheed increases engineering staff

Diversification at Lockheed is resulting in more and better careers for engineers.

New career positions have been created by such diverse projects as radar search planes, turbo-prop and turbo-compound transports, jet transports, vertical rising aircraft, extremely high speed jet fighters, trainers, patrol bombers and a number of classified activities.

To the career-conscious engineer, this diversified development and production program means: 1) more job security and 2) more opportunity for promotion with so many projects in motion.

Positions open include:

DESIGN ENGINEERS

at all levels for creative design in structures, hydraulics, mechanical and electrical fields.

Requirements: An engineering degree or equivalent experience; some aircraft experience preferred.

STRESS and STRUCTURES ENGINEERS

at all levels to perform analysis of structural and mechanical components which determine design criteria.

Requirements: An engineering degree and experience in aircraft structures or related fields.

WEIGHT ENGINEERS

to perform weight analysis and projections during preliminary design, production design and flight test.

Requirements: A degree in engineering, mathematics or physics with experience in weight control and estimations.

Lockheed

Aircraft Corporation

Burbank **California**

Training Program for Non-Aircraft Engineers
Aircraft experience is not necessary to join Lockheed. An engineering degree or equivalent experience qualifies you to receive transitional or on-the-job training—at full pay.

Lockheed offers you increased salary rates now in effect; generous travel and moving allowances; an opportunity to enjoy Southern California life; and an extremely wide range of employee benefits which add approximately 14% to each engineer's salary in the form of insurance, retirement pension, sick leave with pay, etc.

Those interested are invited to write E. W. Des Lauriers for an application blank and illustrated brochure describing life and work at Lockheed. Coupon below is for your convenience.

Mr. E. W. Des Lauriers, Dept. MD-12
Lockheed Aircraft Corporation, 1708 Empire Ave., Burbank, Calif.
Dear Sir:
Please send me your Lockheed brochure describing life and work at Lockheed in Southern California.

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I AM INTERESTED IN ... *(name position in this advertisement which fits your training and experience)*

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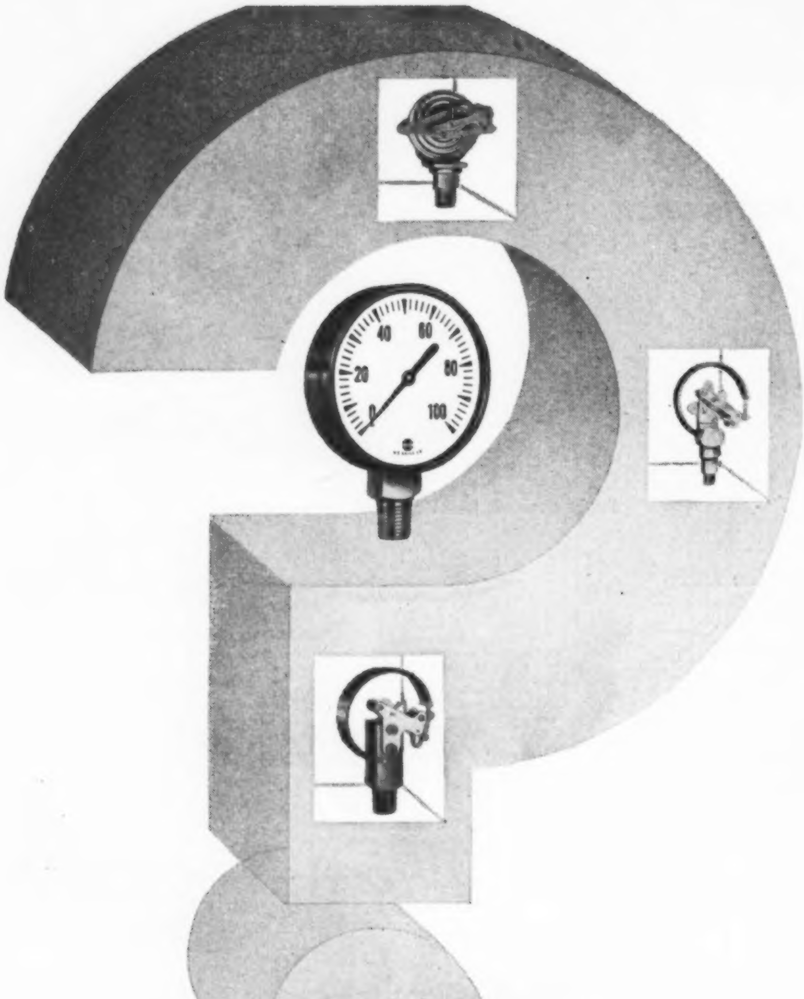


is there a "STOCK" answer to your "SPECIAL" gauge problems?

There may very well be, because USG manufactures and stocks more than 200,000 standard gauges and a complete line of gauge components to meet practically every pressure sensing and indicating requirement.

Chances are that, with slight modification, a stock gauge will fulfill your very needs . . . eliminating the expense of special gauge design, engineering and production. USG's special background, experience and resources are ready to assist you with all problems relating to gauges or other pressure actuated devices.

A call to your nearest USG District Office, or, a letter to us at Sellersville is all that you need to determine whether we can supply a "standard" from stock . . . or, whether your application requires a "special"

USG UNITED STATES GAUGE *Gauge Headquarters* for over 50 years

United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Penna.

USG'S RESOURCES HELP DESIGN ENGINEERS MATCH SPECIFICATIONS

Performance and price are two factors every design engineer must consider carefully when specifying gauges.

Most engineers know of USG's record of leadership in gauge design and precision engineering—for over 50 years USG has been designing and producing gauges for more Original Equipment Manufacturers than any other instrument company in the world.

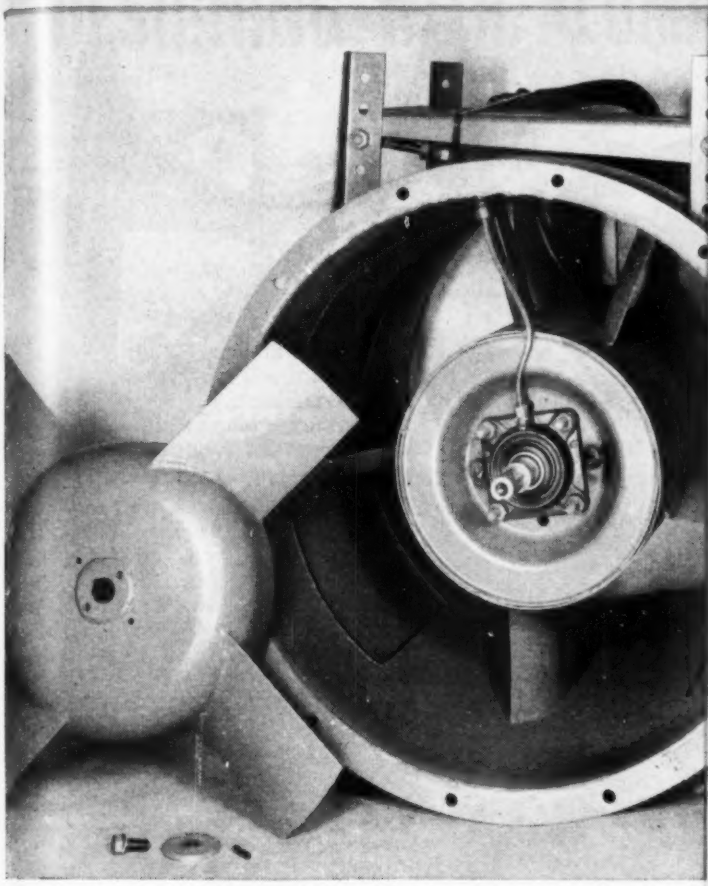
Many engineers don't know, however, that USG maintains the world's largest stock of gauge components to meet practically any pressure sensing device or pressure actuator application. These components are stocked by USG *specifically to eliminate expensive special production.*

In addition to the components for special gauge designs, USG inventories over 200,000 standard gauges in a variety of types, sizes and ranges for practically every industry application. Many stock gauges carried by USG are expensive special production items with other gauge manufacturers.

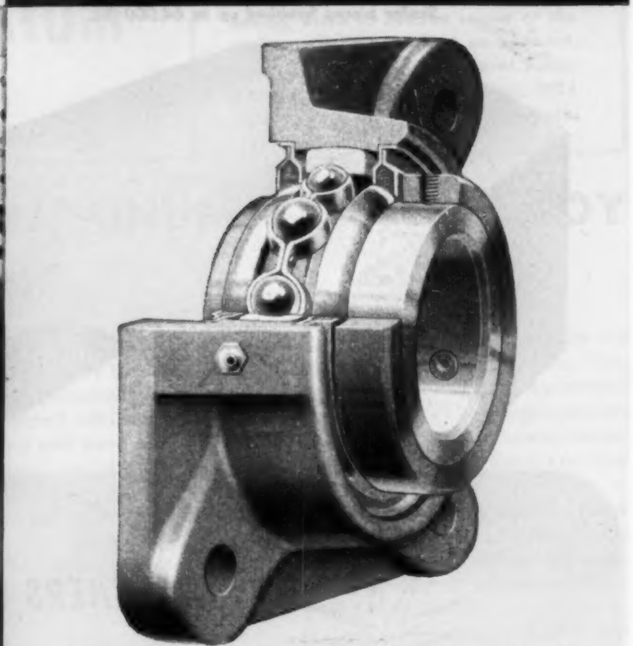
USG provides highest quality gauges at competitive prices because its facilities are economically integrated for large volume, quality controlled production. Gauge for gauge—in every application and classification—*in every price class*—USG has more to offer than any other make!

Above, a portion of USG's Research Laboratory. Here constant testing of materials under customer operating conditions assures optimum efficiency and long gauge life.

BEARING PROBLEM? READY ANSWER:

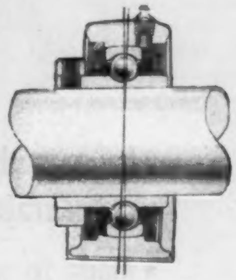


This Vaneaxial fan built by American Blower Corporation revolves on two Link-Belt Ball Bearing Flanged Blocks.



Series 300 Ball Bearing Flanged Blocks are part of Link-Belt's complete line of pillow blocks, flanged, flanged cartridge, cartridge, take-up and hanger blocks and unmounted bearings.

AUTOMATIC RELIEF OF EXCESS GREASE PRESSURE. No danger of seal being forced out . . . no chance for high pressure to damage bearing.



FREE ALIGNING ACTION is afforded by enclosed lubricated aligning surfaces . . . assures freedom from wear under severe conditions.

American Blower uses LINK-BELT ball bearing flanged blocks on new axial fans

For satisfactory operation, axial fan bearings must maintain alignment at high speeds . . . retain lubricant . . . resist dust and grit forced through the air at high velocity. For this demanding service, American Blower Corporation uses Link-Belt ball bearing flanged blocks.

Design refinements make these bearings particularly suited to such demands. Minimum support space is required by the sturdy, compact housing positioned on supports inside the fan. In addition, Link-Belt's exclusive housing seal—common to both ball and roller bearings—provides protection from moisture, dust and dirt. All aligning surfaces are completely enclosed within the lubricant chamber.

Whatever your shaft support requirements, contact your nearest Link-Belt office. Let a bearing engineer show you why Link-Belt bearings are so widely used on America's hardest-working machines . . . and they can be supplied from factory branch stores and authorized stock carrying distributors. Or write for Data Book 2550 to get full engineering information on industry's most complete line of mounted and unmounted ball and roller bearings.

LINK-BELT

BALL and ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

This large 16,000 lb. rough machined alloy steel forging will be the heart of an intricate weldment which our customer will fabricate. Similar pieces furnished up to 64,000 lbs.

This weldment is one of several supplied for supporting two large pipe lines. Height—6'.

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- **Made to your specifications and requirements**

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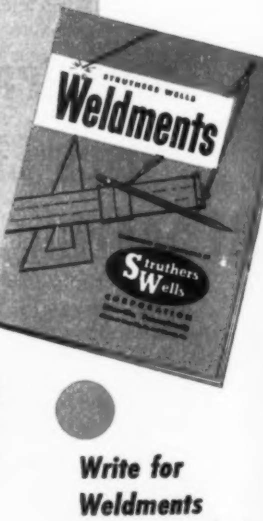

Adjustable rolling mill base—25' long—fabricated from heavy structural shapes and plates.

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DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 9

CHOOSING AN ALUMINUM CASTING ALLOY & HEAT-TREATMENT

Choosing the proper aluminum casting alloy and heat-treatment requires a complete knowledge of the service conditions of the part under consideration, as well as of the alloys, heat treatments, and various casting methods in common use.

There are over thirty recognized casting alloys, with as many as five different heat-treatment possibilities for some, which results in quite a formidable number of choices. From these available alloy and heat-treatment combinations the possible range of typical mechanical properties varies widely as can be seen in the following table:

TABLE 1 Range of Mechanical Properties of Cast Aluminum Alloys

Ult. Tensile Strength	19,000 to 46,000 PSI
Yield Strength	8,000 to 43,000 PSI
Elongation	Zero to 14% in 2"
Fatigue	5,500 to 23,000 PSI
Brinell Hardness	40 to 140

The physical properties likewise, vary over a broad range as shown below:

TABLE 2 Range of Some Physical Properties of Cast Aluminum Alloys

General foundry characteristics	Fair to Excellent
Susceptibility to hot-shortness	Appreciable to Very Little
Ability to be cast in thin sections	Fair to Excellent
Leak tightness	Fair to Excellent
Internal shrinkage	Considerable to Very Little
Machinability	Fair to Excellent
Weldability	Not Recomended to Excellent
Resistance to certain chemicals and compounds	Can't use to Recommended
Strength at elevated temperatures	Low to Moderate
Resistance to corrosion	Fair to Excellent
Impact, or shock-load resistance	Poor to Excellent
Thermal conductivity	.21 to .45 CGS units @ 25°C
Electrical conductivity	21 to 50% of copper (equal volume basis)
Stability to low temperature aging	Low stability to stable

Because of this wide range of properties from which to select, it is recommended that the alloy and heat-treatment be determined by the designer, rather than by the foundryman, because usually the designer has all the data which affect the choice. The foundry should be consulted, but should not be the sole judge. Other factors, each equally as important as foundry characteristics, enter into the alloy and heat-treatment selection.

The designer usually knows which property is required to the fullest extent for the part in question. This should, theoretically, make it fairly easy to select the correct combination from the tables, by merely choosing the one that has the desired property to the maximum degree. But unfortunately, castings having the desired ultimate strength for instance, may not have the required elongation or shock resistance, nor the desirable foundry characteristics. Another having the desired foundry characteristics may not have the required strength and machining properties.

Still another combination may have the required mechanical properties, foundry characteristics and corrosion resistance, but because of size and shape of casting, cannot be given the theoretically ideal heat-treatment. Compromises will have to be made in almost all cases and this can best be done by the designer. In fact, it will sometimes be necessary to actually change the design of part in order to make it adaptable for production in a given alloy and heat-treatment or to cast it by a certain process.

Factors to Consider

To enable the designer to make best alloy and heat-treat recommendations, he should be familiar with production and service requirements. He should also have a fair working knowledge of the aluminum alloys, heat treatments, and of the possibilities and limitations of the various casting processes.

The production and service requirements have a large bearing on the casting method, as do size and shape of part. For example, castings required in fairly large numbers, should be made either by permanent mold or die casting process, provided the size and design features of casting and available alloys are suitable.

Sand casting process is usually confined to producing parts required in small quantities, those having hollow cavities and complex arrangement of ribs, pockets, etc., and to those whose size makes them unsuited for casting in metal molds. In many cases it will be advantageous to redesign a part to make it adaptable for production by either permanent mold or die casting method.

Once the casting method is determined, the alloy choice is narrowed down appreciably.

Next to be considered are the service requirements. If high strength is necessary, that ordinarily eliminates the unheat-treatable alloys unless sufficient metal can be added to compensate for the lower mechanical properties. This can be further and rapidly narrowed down when the remaining requirements such as leak tightness, corrosion resistance, machinability and others are considered.

In some instances, one certain property may be required to the maximum degree—for example, highest possible yield. This immediately narrows down the alloy and heat treatment choice as well as casting method to a possible one or two, and bigger compromises will have to be made for the other requirements.

In other cases the large size and shape of casting may not permit the safe use of a "solution heat-treatment," but will limit it to use of a "straight aging treatment" taking place in approximate temperature range of 300° F to 500° F, or to no treatment at all, thereby sacrificing, to a degree, some of the mechanical properties and slightly decreasing machinability.

The reason for this limitation is the fact that the first half of a solution heat-treatment takes place at a temperature ranging between 930° F to 1,000° F, followed by rapid quench in water. At those temperatures, the mechanical strength of aluminum is practically zero and therefore certain large unsupported areas of the casting, or the whole casting at times, may sag or distort from its own weight. Sometimes the size and shape of part are such that it can withstand the effects of the high temperatures but cannot be quenched without danger of warping or cracking.

Die castings are always used in the as-cast condition, which limits the choice to one of alloy selection only.

To assist the designer in becoming familiar with the various casting processes, mechanical properties, and physical properties we refer him to these tables on the following pages:

Table #3—Typical Mechanical Properties of Aluminum Sand Castings

Table #4—Typical Mechanical Properties of Aluminum Permanent Mold Castings

Table #5—Typical Mechanical Properties of Aluminum Die Castings

Table #6—Alloy selection Guide

PLEASE TURN TO NEXT PAGE ➡

SAND CASTING ALLOYS—TABLE 3

Alloy	H. T.[3]	Typical Mechanical Properties[1]					Casting and Service Characteristics[2]						
		Tensile Strength psi	Yield Strength psi	Elongation Per Cent in 2"	Hardness Brinnell 10/500	Fatigue psi	Feeding Ability	Pressure Tightness	Hot-Shortness	General Cast-ability	Machin-ability	Corrosion Resist-ance	Weld-ability[5]
43	AC	19,000	8,000	8.0	40	6,500	E	E	VL	E	F	E	VG
	AC	21,000	14,000	2.5	55	8,000	E	E	MIN	VG	G	G	G
	AC	24,000	15,000	1.5	70	9,000	F	F	MOD	G	G	G	F
	AC	24,000	15,000	1.5	70	9,000	G	G	MOD	G	G	G	G
122	T2	27,000	20,000	1.0	80	9,500	G	VG	MOD	G	E	F	F
122	T61	41,000	40,000	(6)	115	8,500	G	VG	MOD	G	E	F	F
142	T21	27,000	18,000	1.0	70	6,500	G	F	AP	F	G	G	F
142	T571	32,000	28,000	.5	85	8,000	G	F	AP	F	G	G	F
142	T77	28,000	25,000	2.0	75	9,500	G	F	AP	F	G	G	F
195	T4[4]	32,000	16,000	8.5	60	6,000	G	G	AP	F	G	G	F
195	T6	36,000	24,000	5.0	75	6,500	G	G	AP	F	VG	G	F
195	T62	40,000	30,000	2.0	90	7,000	G	G	AP	F	E	G	F
212	AC	23,000	14,000	2.0	65	8,000	G	G	MOD	G	E	G	G
214	AC	25,000	12,000	9.0	50	5,500	F	F	MOD	F	E	E	G
B214	AC	20,000	13,000	2.0	50	....	G	F	MOD	F	E	E	G
F214	AC	21,000	12,000	3.0	50	....	G	F	MOD	F	E	E	G
220	T4	46,000	25,000	14.0	75	7,000	F	F	MOD	F	E	E	G
319	AC	27,000	18,000	2.0	70	10,000	G	E	VL	VG	G	G	G
319	T6	36,000	24,000	2.0	80	10,000	G	E	VL	VG	G	G	G
355	T51	28,000	23,000	1.5	65	7,000	E	E	VL	E	E	VG	VG
355	T6	35,000	25,000	2.5	80	8,500	E	E	VL	E	E	VG	VG
355	T61	39,000	35,000	1.0	90	....	E	E	VL	E	E	VG	VG
355	T7	38,000	36,000	0.5	85	8,500	E	E	VL	E	E	VG	VG
355	T71	35,000	29,000	1.5	75	10,000	E	E	VL	E	G	VG	VG
356	T51	25,000	20,000	2.0	60	7,500	E	E	VL	E	G	E	VG
356	T6	33,000	24,000	4.0	70	8,000	E	E	VL	E	G	E	VG
356	T7	34,000	30,000	2.0	75	....	E	E	VL	E	E	E	VG
356	T71	28,000	21,000	4.5	60	....	E	E	VL	E	G	E	VG

NOTES:

1. Properties determined on standard tensile test bars cast under favorable conditions and properly heat-treated, when applicable.
2. Ratings: E, excellent; VG, very good; G, good; F, fair—apply to all castings and service characteristics except Hot-Shortness; MOD, moderate; VL, very little; AP, appreciable; MIN, minor—applies to Hot-Shortness only.
3. AC, as cast.
4. On standing at room temperature for several weeks, properties approach those of T6 condition.
5. Weld before heat-treating, using appropriate filler rod.
6. Less than 0.5% elongation.

PERMANENT MOLD CASTING ALLOYS—TABLE 4

Alloy	H. T.[3]	Typical Mechanical Properties[1]					Casting and Service Characteristics[2]						
		Tensile Strength psi	Yield Strength psi	Elongation Percent in 2"	Hardness Brinnell 10/500	Fatigue psi	Feeding Ability	Pressure Tightness	Hot-Shortness	General Cast-ability	Machin-ability	Corrosion Resist-ance	Weld-ability[5]
43	AC	23,000	9,000	10.0	45	....	E	E	VL	E	F	E	VG
A108	AC	28,000	16,000	2.0	70	....	E	G	MIN	VG	G	G	G
	AC	28,000	19,000	2.0	70	....	F	G	MOD	F	G	F	F
	AC	30,000	24,000	1.0	80	9,500	G	VG	VL	G	G	G	G
122	T52	35,000	31,000	1.0	100	....	G	G	MOD	G	E	F	F
122	T551	37,000	35,000	......	115	8,500	G	G	MOD	G	E	F	F
122	T65	48,000	36,000	......	140	9,000	G	G	MOD	G	E	F	F
A132	T551	36,000	28,000	.5	105	13,500	F	VG	VL	F	F	G	G
A132	T65	47,000	43,000	.5	125	....	F	VG	VL	F	F	G	G
D132	T5	36,000	28,000	1.0	105	13,500	G	VG	MIN	G	F	G	G
138	AC	30,000	24,000	1.5	100	....					G		
142	T571	40,000	34,000	1.0	105	10,500	F	F	AP	F	VG	G	F
142	T61	47,000	42,000	.5	110	9,500	F	F	AP	F	VG	G	F
B195	T4[4]	37,000	19,000	9.0	75	9,500	F	F	MOD	F	G	G	G
B195	T6	40,000	26,000	5.0	90	10,000	F	F	MOD	F	G	G	G
B195	T7	39,000	20,000	4.5	80	9,000	F	F	MOD	F	G	G	G
A214	AC	27,000	16,000	7.0	60	....	F	F	AP	F	E	E	G
	AC	34,000	19,000	2.5	85	....	G	G	VL	G	G	G	G
	T6	40,000	27,000	3.0	95	....	G	G	VL	G	G	G	G
	AC	34,000	19,000	2.0	90	14,500	G	G	VL	G	F	G	G
	T5	34,000	25,000	1.0	100	12,000	G	G	VL	G	F	G	G
	T6	42,000	30,000	1.5	105	15,000	G	G	VL	G	F	G	G
	T7	37,000	28,000	2.0	90	12,000	G	G	VL	G	F	G	G
355	T51	30,000	24,000	2.0	75	....	E	E	VL	E	VG	VG	VG
355	T6	43,000	27,000	4.0	90	10,000	E	E	VL	E	VG	VG	VG
355	T62	45,000	40,000	1.5	105	10,000	E	E	VL	E	E	VG	VG
355	T7	40,000	30,000	2.0	85	10,000	E	E	VL	E	VG	VG	VG
355	T71	36,000	31,000	3.0	85	10,000	E	E	VL	E	VG	VG	VG
356	T6	40,000	27,000	5.0	90	13,000	E	E	VL	E	G	E	VG
356	T7	33,000	24,000	5.0	70	11,000	E	E	VL	E	G	E	VG
363	AC	35,000	23,000	2.7	85	....	E	VG	VL	E	E	G	E
363	T6	48,000	28,000	6.5	90	....	E	VG	VL	E	E	VG	E

NOTES:

1. Properties determined on standard tensile test bars cast under favorable conditions and properly heat-treated, when applicable.
2. Ratings: E, excellent; VG, very good; G, good; F, fair—apply to all castings and service characteristics except Hot-Shortness; MOD, moderate; VL, very little; AP, appreciable; MIN, minor—applies to Hot-Shortness only.
3. AC, as cast.
4. On standing at room temperature for several weeks, properties approach those of T6 condition.
5. Weld before heat-treating, using appropriate filler rod.

DIE CASTING ALLOYS—TABLE 5

Alloy	Condition[3]	Typical Mechanical Properties[1]					Casting and Service Characteristics[2]					
		Tensile Strength psi	Yield Strength psi	Elongation Per Cent in 2"	Hardness Brinnell 10/500	Fatigue psi	Mold Filling Capacity	Hot-Shortness	General Castability	Machin-ability	Corrosion Resistance	Weld-ability
13	AC	39,000	21,000	2.0	---	19,000	VG	VL	VG	F	VG	not
A 13	AC	35,000	16,000	3.5	---	....	VG	VL	VG	F	VG	recom-
43	AC	30,000	16,000	9.0	---	17,000	G	MIN	G	F	VG	mended
85	AC	40,000	24,000	5.0	---	22,000	G	MOD	G	F	VG	"
218	AC	45,000	27,000	8.0	---	23,000	F	AP	F	E	E	"
360	AC	44,000	27,000	3.0	---	19,000	E	VL	E	F	G	"
A360[4]	AC	41,000	23,000	5.0	---	18,000	E	VL	G	F	E	"
	AC	45,000	26,000	2.0	---	20,000	VG	MOD	G	G	G	"
	AC	46,000	25,000	3.0	---	19,000	VG	MOD	G	G	G	"
	AC	46,000	27,000	1.0	---	21,000	VG	MOD	G	F	G	"

NOTES:

1. Properties determined from standard test bars cast under favorable conditions.
2. Ratings: E, excellent; VG, very good; F, fair—apply to all castings and service characteristics except "hot-shortness"; MOD, moderate; VL, very little; AP, appreciable; MIN, minor—apply to "hot-shortness" only.
3. As cast.
4. In A360 and A380, the iron content is controlled more closely than in 360 and 380 alloys.

SELECTION GUIDE—TABLE 6

Major Property Wanted	Sand Cast	Perm. Mold	Die Cast
General purpose— Low strength arranged in order of decreasing castability	43 108 212 214	43 A108 A214	43 A 13 13
General purpose— Heat-treated[1] good balance of all properties for most applications	355-T6 356-T6 19-ST6	355-T6 356-T6 B19-ST6	380 A380 360 A360
Best castability for complex castings with thin sections—arranged in order of decreasing castability	43 108 356 355	43 A108 356 355	A360; 360 A 13; 13 43
High ductility and **shock resistance** arranged in order of decreasing properties	220-T4 195-T4 356-T6 214[2] 43	363-T6 B195-T4 356-T6 A214 43	218 A360 43
Pressure tight—Low stressed	43 108	43 A108	A360 A 13 43
Pressure tight—High stressed	356 355	356 355 363	A360

Major Property Wanted	Sand Cast	Perm. Mold	Die Cast
Corrosion Resistance	43 214 220 356 355	43 A214 356 355 363	218 A360
Ornamental and Architectural Applications—also food handling, dairy equipment, cooking utensils and marine fittings	43 214[2] B214[2] F214[2]	43 A214[2]	43 218[2]
Piston Alloys—good properties at operating temperatures	122 142	122 A132 D132 142	384
Other alloys having good properties at moderate temperatures	214	138 A214	13 360
Good machinability— Heat-treated castings machine better than those in as-cast condition, and generally those having highest hardness machine better than the softer ones in any one alloy	122 212 214 B214 F214 220-T4 195	122 355 363 A214 A108	218 A380

NOTES:

1. Except die castings.
2. These alloys take anodized finish without appreciable discoloration.

More detailed assistance with design, alloy selection, fabrication, and heat-treatment procedure is obtainable through any Kaiser Aluminum sales office located in principal cities, or write to Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

Kaiser Aluminum

see our catalog in PRODUCT DESIGN FILE or write for copy

Setting the pace—in growth, quality and service

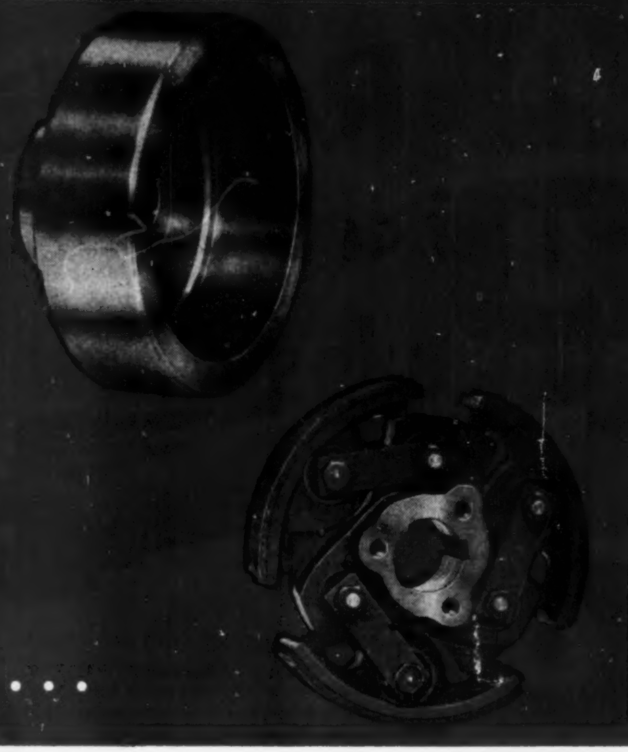
THE *New* HILLIARD

TWIFLEX

AUTOMATIC CENTRIFUGAL CLUTCH COUPLING

with

Flexible ACTION . . .



11 NEW IMPORTANT FEATURES . . .

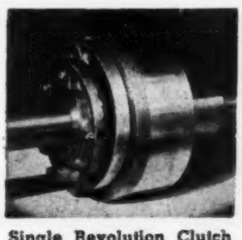
1. Flexible in all directions.
2. Absorbs shock.
3. Limits torsional vibration.
4. Has adjustable idle speed.
5. Can be furnished in automatic free-wheeling type.
6. Smooth starting.
7. No slip under normal load at full speed.
8. Protects driver and driven mechanisms against overload shock.
9. Can be furnished in automatic back-stop type.
10. Prevents torsional resonance.
11. Easily assembled even in blind installations.

If you have problems of misalignment — smooth starting — vibration — overload — or assembly in the manufacture or operation of:

- COMPRESSORS
- BLOWERS
- DIESEL ENGINES
- EXCAVATORS
- REFRIGERATION EQUIPMENT
- TEXTILE MACHINERY
- WIRE DRAWING MACHINES
- FANS
- GASOLINE ENGINES
- BACK STOP BRAKES
- CONVEYORS
- BALL MILLS
- ELECTRIC MOTORS
- GENERATORS
- HIGH SPEED PULVERIZERS
- LARGE OVERHEAD CRANES
- HAMMER MILLS
- MIXERS
- TUBE MILLS
- PUMPS

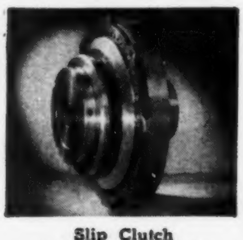
• LET OUR ENGINEERS CONSIDER YOUR PROBLEMS. TWIFLEX MAY BE THE ANSWER.

THE HILLIARD LINE OF CLUTCHES •



Single Revolution Clutch
Write for Bul. 239

Over-Running Clutch
Write for Bul. 231



Slip Clutch
Write for Bul. 300

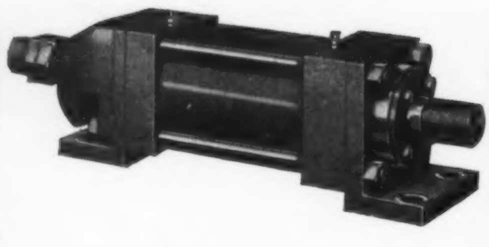
• *WRITE TODAY!*
for details of TWIFLEX Coupling in Catalog CE-3
•

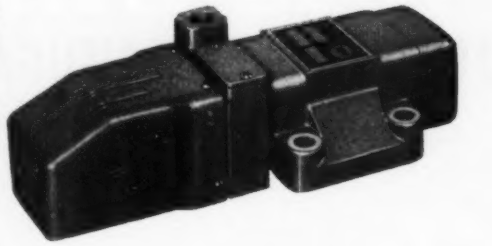
THE HILLIARD *Corporation* 103 W. FOURTH ST., ELMIRA, N. Y.

A U T O M A T I O N

Realistic Planning

CALLS FOR PRACTICAL EXPERIENCE


AIR AND OIL HYDRAULIC CYLINDERS


AUTOMATICALLY CONTROLLED VALVES

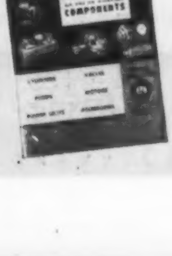
HPM


VARIABLE VOLUME HYDRAULIC PUMPS


PACKAGED POWER UNITS

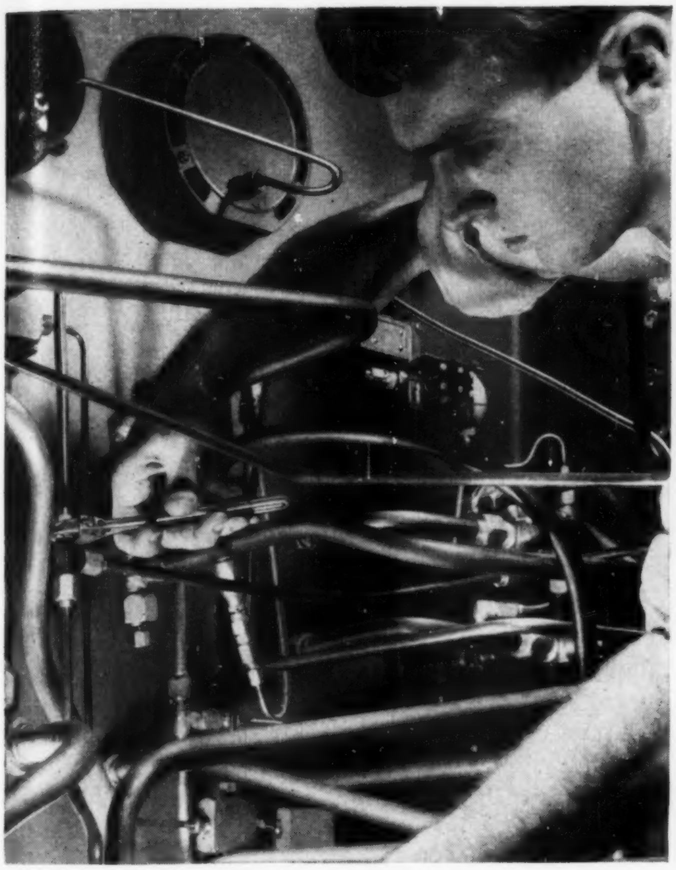
For over three-quarters of a century H-P-M engineers have designed equipment — and motions — for varied requirements. Now, with a complete line of air and hydraulic components as part of our standard line you are assured of complete responsibility for your automatic systems. The hydraulic cylinders, valves, pumps and power units illustrated are typical of the air and oil hydraulic equipment in the H-P-M line. Call in the H-P-M Field Engineer in your locality when power, or the control of power, is your problem. The experience of the H-P-M organization will be of real assistance.

1096 Marian Road



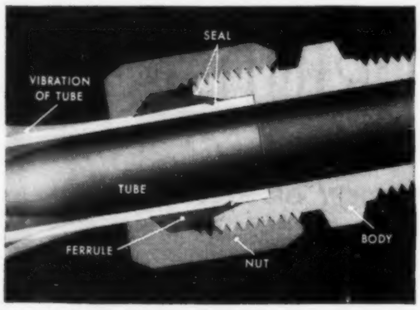
This 28-page condensed catalog covers the complete H-P-M line of hydraulic components. Write for your copy.
Dept. A.

HYDRAULIC POWER DIVISION
THE HYDRAULIC PRESS MFG. CO.
MOUNT GILEAD, OHIO, U. S. A.

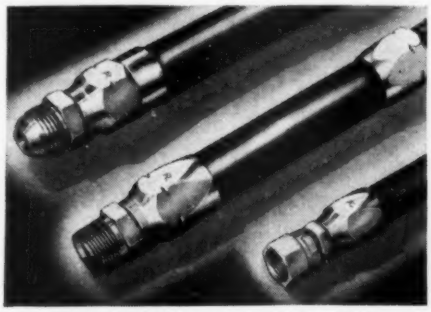


"Tube up and forget it" with leakproof Parker fittings

Triple-lok flare fittings are the easiest, fastest and safest way to tube up even in close quarters. They are absolutely leakproof even under the severest conditions of vibration, high pressures and temperatures. *Triple-lok* fittings meet J.I.C. and S.A.E. Standards plus specifications of the A.S.M.E. Code for Pressure Piping. Available for tubing outside diameters from 1/8 through 2 inches. More *Triple-lok* fittings are used on industrial machinery than any other fittings.

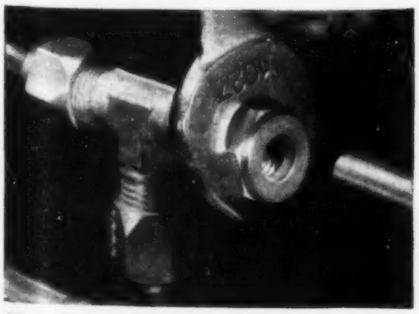


Ferulok flareless fittings, featuring the visible "bite", are especially for high-pressure, heavy-wall tubing. Cutaway shows why vibration won't break the seal.

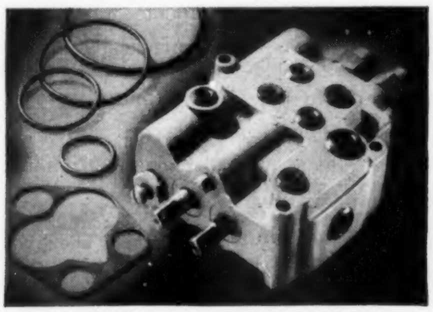


New Hoze-lok fittings and hose assemblies (for medium and high-pressure hydraulic service) offer better performance, easier make-up, greater re-usability.

New Weld-lok fittings are machined from high-quality steel or stainless-steel bar stock and forgings. They are available for tubing 1/4 through 2 inches, O.D.



New Intru-lok tube fittings can be quickly installed by anyone. Simply push tube in, then tighten nut. Designed for instrumentation lines of 1/4 through 1/2 inch, O.D.



Other Parker products include new hydraulic control valves, check valves, accumulators and O-rings. Mail the coupon for the fitting catalogs you want.

TUBE AND HOSE FITTINGS DIVISION
Section 411

The Parker Appliance Co.
17325 Euclid Avenue
Cleveland 12, Ohio

- ☐ Send Triple-lok & Ferulok Catalog No. 4300
- ☐ Hoze-lok Catalog No. 4400
- ☐ Weld-lok Catalog No. 4370
- ☐ Intru-lok Catalog No. 4320A1

Name ________________ Title ________

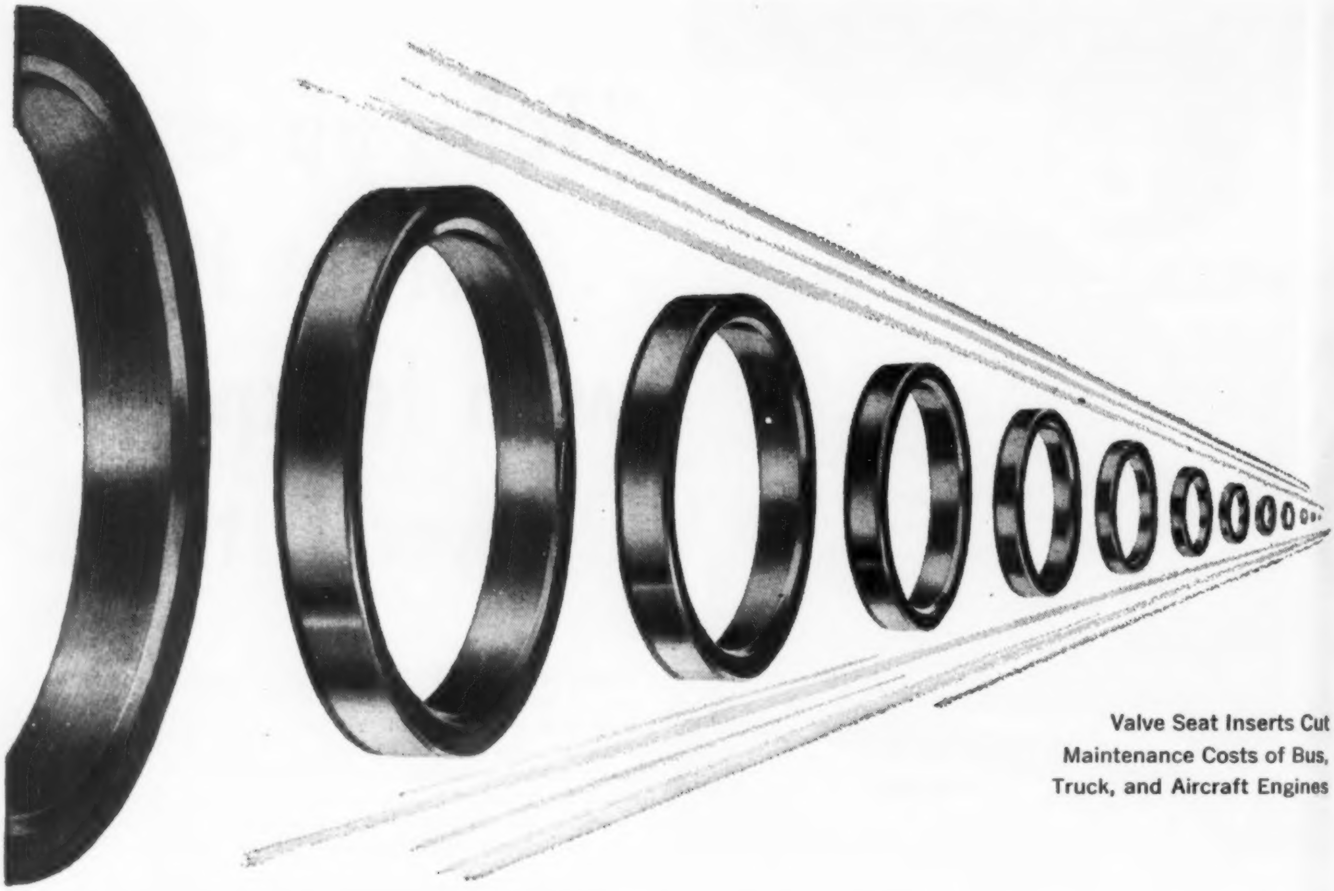
Company ________________

Address ________________

City ________________ State ________

Parker

Hydraulic and fluid system components



Valve Seat Inserts Cut Maintenance Costs of Bus, Truck, and Aircraft Engines

200,000 MILES BETWEEN GRINDS

Valve seat inserts made from HAYNES STELLITE alloy have given as much as 200,000 miles of service in truck engines before regrinding was required. These inserts stand up under continuous impact without cracking. They won't stretch or distort even under abnormal operating temperatures, and will retain their hardness even at high temperatures.

RESIST WEAR . . . CORROSION . . . OXIDATION

The wear, corrosion, and oxidation-resistant qualities of HAYNES STELLITE alloy valve seat inserts further insure peak performance at low maintenance costs. These cobalt-base parts resist the erosive effects of hot exhaust gases. They are practically unaffected by corrosives present in the fuel, and will not pound in at high operating temperatures.

AVAILABLE IN A VARIETY OF SIZES

The inserts can be supplied in a variety of sizes for use in bus, truck, aircraft, marine, and other types of internal combustion engines. The unusual properties of HAYNES STELLITE alloy make it possible to produce efficient inserts as thin as $\frac{5}{32}$-in. in cross-section. Use of these thin inserts enables the engine designer to locate water jackets closer to actual valve seating surfaces, and provide a more effective cooling system.

For full information on sizes, and prices, write to Haynes Stellite Company, 725 South Lindsay Street, Kokomo, Indiana.

"Haynes" and "Haynes Stellite" are registered trade-marks of Union Carbide and Carbon Corporation.

HAYNES
TRADE-MARK
ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago · Cleveland · Detroit · Houston · Los Angeles · New York · San Francisco · Tulsa

What FAWICK 3-POINT ADVANTAGES MEAN TO *Your* MACHINE

FAWICK CLUTCH & BRAKE ENGINEERING

DESIGN

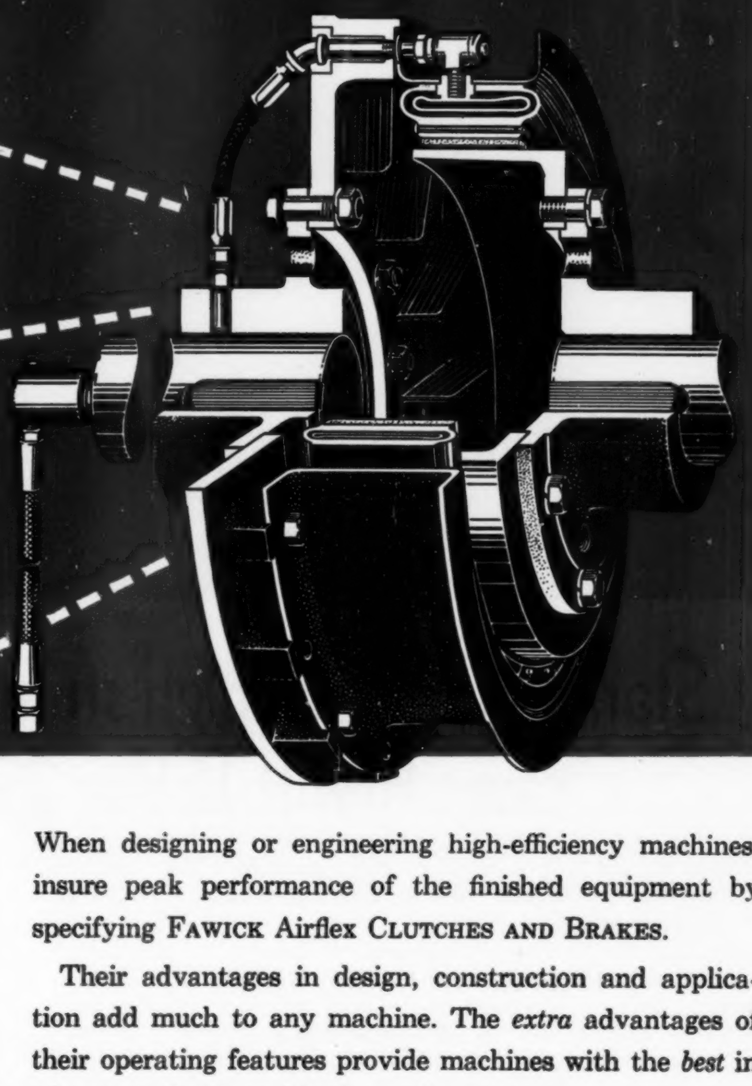
Fawick Airflex represents advanced clutch and brake engineering at its best! The principle of a radial type clutch with power transmitted through the sidewalls of the rubber actuating tube makes possible its simplified design.

CONSTRUCTION

The rugged construction of Fawick units provides exceptional strength for long trouble-free service even under the most severe operating conditions.

APPLICATION

Fawick Airflex units are easily adapted to all types of applications. The reduced number of parts and elimination of mechanical linkages make possible compact installation on all types of machinery.



When designing or engineering high-efficiency machines, insure peak performance of the finished equipment by specifying FAWICK Airflex CLUTCHES AND BRAKES.

Their advantages in design, construction and application add much to any machine. The *extra* advantages of their operating features provide machines with the *best* in advanced clutch and brake performance.

FAWICK *Plus* ADVANTAGES IN MACHINE OPERATION

COOLER CLUTCH OPERATION

•

CUSHIONED DEPENDABLE ACTION

•

SELF-ADJUSTMENT FOR WEAR

•

LONG LIFE — LOW MAINTENANCE

FAWICK AIRFLEX DIVISION

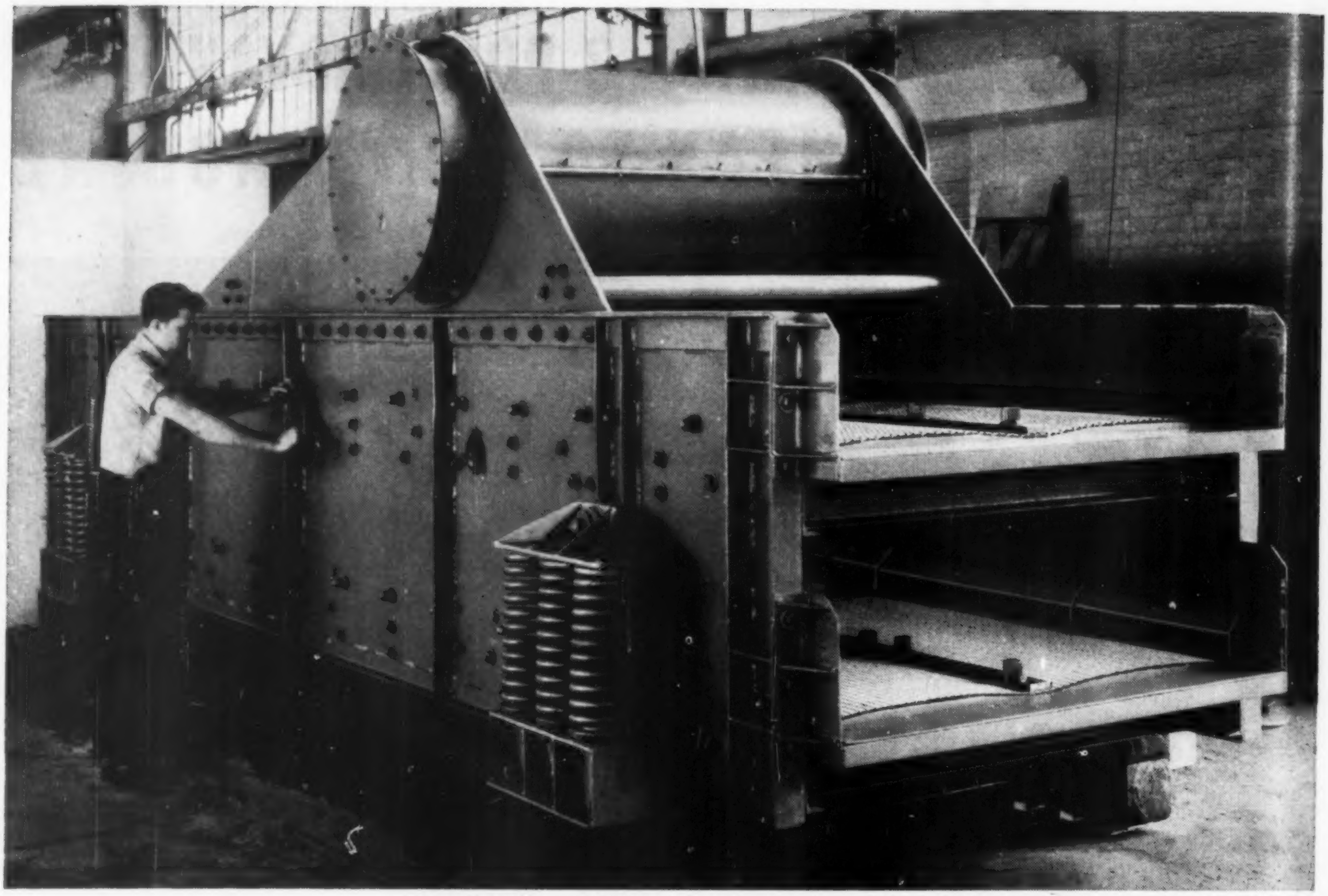
FAWICK CORPORATION

9919 CLINTON ROAD • CLEVELAND 11, OHIO

FAWICK Airflex

INDUSTRIAL CLUTCHES AND BRAKES

For further information on Fawick Industrial Clutch and Brake Units, write to the Main Office, Cleveland, Ohio, for Bulletin 400-A.



ASSEMBLING an RB&W high-strength bolt on Hewitt-Robins' new Eliptex vibrating machine.

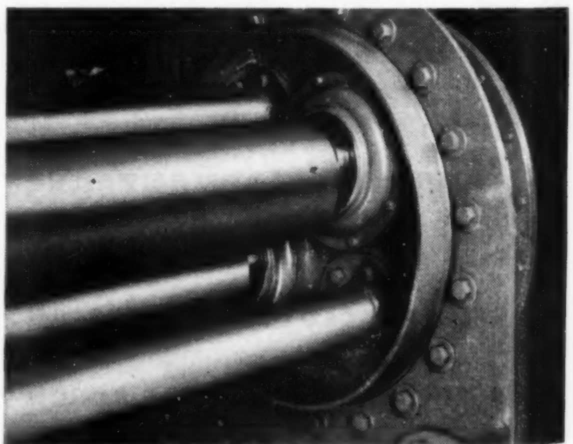
Standardizing on high-strength bolts saves Hewitt-Robins 25%—improves product!

Take a hard look at your fastening operations and you may find you will save a lot by using standard high-strength bolts instead of expensive specials.

Using a standard RB&W high-strength bolt plus a heavy semi-finished nut with two hardened washers, Hewitt-Robins is getting these advantages and savings on vibrating machines: 1. Saving 25% in yearly fastener cost. 2. Eliminating situations requiring body-bound connections with attendant reaming operations. 3. Eliminating all special, finished bolts with varied thread lengths and also all special lock nuts. 4. Eliminating procurement problems and slow delivery of specials. 5. Reducing nut and bolt inventory. 6. Obtaining better performance and lower maintenance on units.

The RB&W product has 2½ to 3 times the clamping force of the previous fasteners. Thus the assembled connection is better able to withstand severe vibration.

Maybe your operation doesn't give fasteners as hard a time as vibrating equipment, but it pays to look into the savings you can expect from specifying standards instead of specials. RB&W has the answers to your questions.



DETAIL VIEW of Hewitt-Robins vibrator, showing RB&W high-strength bolts which must resist shear stress as well as vibration. 4.8

See our insert on high-strength bolts in Sweet's Architectural and Industrial Construction Files.

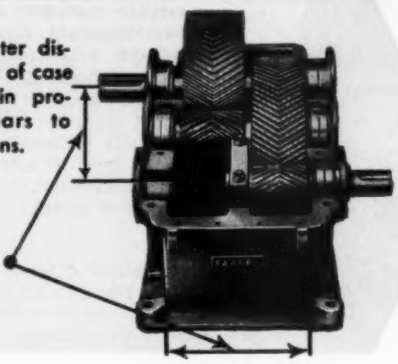
RB&W **RUSSELL, BURDSALL & WARD**

109 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: PORT CHESTER, N.Y.; CORAOPOLIS, PA.; ROCK FALLS, ILL.; LOS ANGELES, CALIF. *Additional sales offices at:* ARDMORE (PHILA.), PA.; PITTSBURGH; DETROIT; CHICAGO; DALLAS; SAN FRANCISCO. *Sales agents at:* NEW ORLEANS, DENVER, SEATTLE. *Distributors from coast to coast.*

3 BIG REASONS

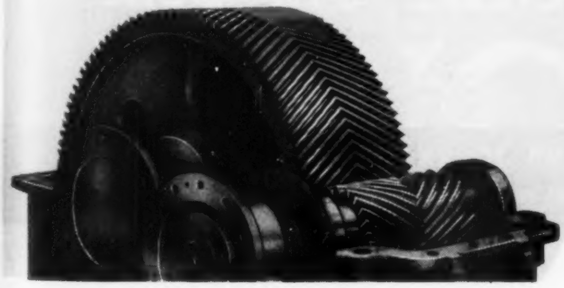
WHY IT PAYS TO SEE FARREL® WITH YOUR SPEED REDUCTION PROBLEM



Relation of center distance and width of case gives latitude in proportioning gears to specific conditions.

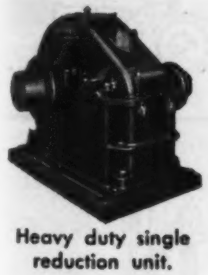
1 *DESIGN FLEXIBILITY*

You can ask for—and get—a Farrel speed reducing unit that will fit your requirements exactly. Gears and pinions can be proportioned to meet specific load, speed and service requirements. Input and output shafts can be varied in size, in material and in extension. Housing dimensions can even be changed to meet problems in mounting.



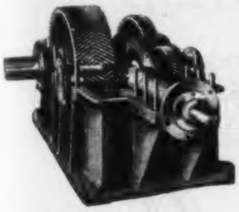
2 *PRECISION GEARS*

Precision generation by the famous Farrel-Sykes method assures accuracy of tooth spacing, tooth contour and helix angle, which pay off in smooth, quiet, uniform power flow. The herringbone design provides evenly distributed pressure over each tooth, from tip to working depth line. This reduces wear and maintains correct tooth action throughout a long gear life.

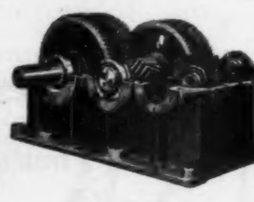


Heavy duty single reduction unit.

Unit with pinion on extended shaft.



Horizontal right angle unit.



Standard double reduction unit.

3 *WIDE RANGE OF RATIOS AND CAPACITIES*

Designs include single, double and multiple reduction units, speed-change units having two or more selective speeds, and drives to meet special requirements. Ratios of single reduction units range from 1½:1 to 10:1. Double reduction units are available in a ratio range from 10:1 to 60:1.

For more about these adaptable units write for Bulletin 449.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

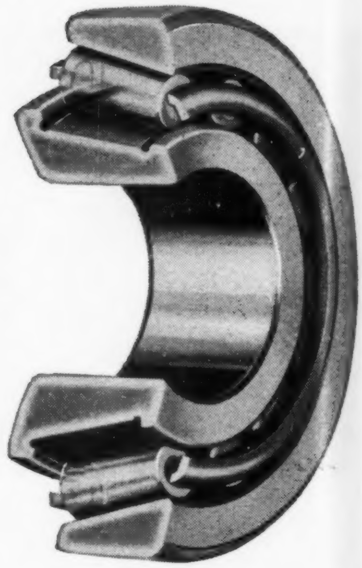
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Akron, Detroit, Chicago, Memphis, Minneapolis, Fayetteville (N.C.), Los Angeles, Salt Lake City, Tulsa, Houston, New Orleans

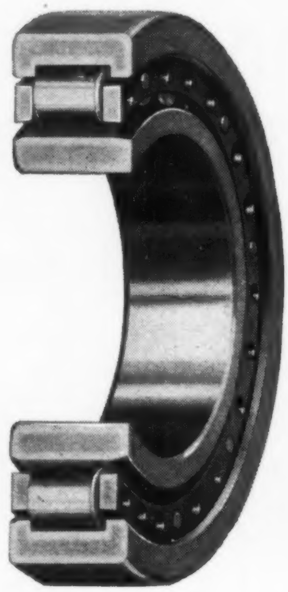
FB-958

Farrel-Birmingham®

WHATEVER YOUR ROLLER BEARING APPLICATION

specify BOWER!





Earthmovers, jet turbine engines, rolling mill equipment, truck axles—you name it! Bower builds a complete line of tapered, straight and journal roller bearings including a size and type to fit *your* product. What's more, these dependable bearings have *proved* themselves in virtually every conceivable type of application. Their built-in quality, skillful engineering and advanced design features provide such important bearing advantages as reduced wear, longer life and lower maintenance requirements. Let a Bower engineer give you full details on the complete Bower line.

BOWER ROLLER BEARING COMPANY
DETROIT 14, MICHIGAN

BOWER TAPERED ROLLER BEARINGS INCORPORATE ADVANCED SPHER-O-HONED DESIGN! Spherically generated roll heads and higher flange with larger, two-zone contact area reduce wear, improve roller alignment and virtually eliminate "end play." This helps hold adjustment and pre-load longer and better. Larger oil groove provides positive lubrication.

BOWER STRAIGHT ROLLER BEARINGS ARE BUILT TO CARRY MAXIMUM LOADS! Integral two-lip race increases rigidity—keeps rollers in proper alignment at all times. Steel cage allows free movement of rollers between races during normal operation. High-grade alloy-steel rollers and races are precision-ground for quieter, smoother operation.

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS
for every field of transportation and industry

BOWER
ROLLER BEARINGS
SPHER-O-HONED

CERTIFIED ZINC ALLOY PLAN
LICENSED PRODUCER
AMERICAN DIE CASTING INSTITUTE

When casting requirements call for ZINC, call Monarch. Since 1938 Monarch has been die-casting zinc for a wide range of applications. Our experience gained in casting both aluminum and zinc allows us to offer unbiased engineering consultation toward adapting the best metal and method for your requirements. Monarch's practical approach to all types of casting and finishing methods has gained increasing acceptance by leading manufacturers—resulting in better end products at lower end cost.

CERTIFIED ZINC CASTINGS OFFERS YOU 5 ADVANTAGES:

- **Excellent strength and ductibility**
- **Closer cast tolerances**
- **Savings on machining**
- **Ease of finishing**
- **Low metal cost in relation to weight**

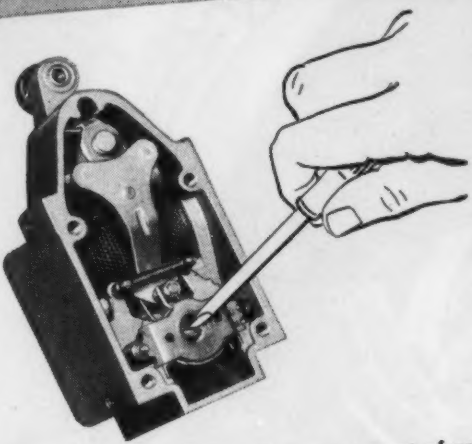
MONARCH ALUMINUM MFG. COMPANY

Detroit Ave. at West 93rd Street
Cleveland 2, Ohio

ALUMINUM Permanent Mold Castings • ZINC Die Castings • Aluminum Die Castings • MACHINING • FINISHING • ASSEMBLY


YOU GET eleven CONTACT ARRANGEMENTS IN one
80 DEGREES OVERTRAVEL
11 CONTACT ARRANGEMENTS
OIL TIGHT
SIMPLE ADJUSTMENT
EASY STOCKING
EASY MOUNTING
RUGGED MECHANISM
CLASS 9007 LIMIT SWITCH
RATING-AMPS
VOLTS A.C. D.C.
125 25 5.0
250 15 1.0
600 15 0.2
SQUARE D COMPANY
MILWAUKEE, WIS. MADE IN U.S.A.
TYPE
Write for Bulletin SM-239
Address Square D Company,
4041 North Richards Street,
Milwaukee 12, Wisconsin
SQUARE D COMPANY

WITH THIS NEW MACHINE TOOL LIMIT SWITCH!

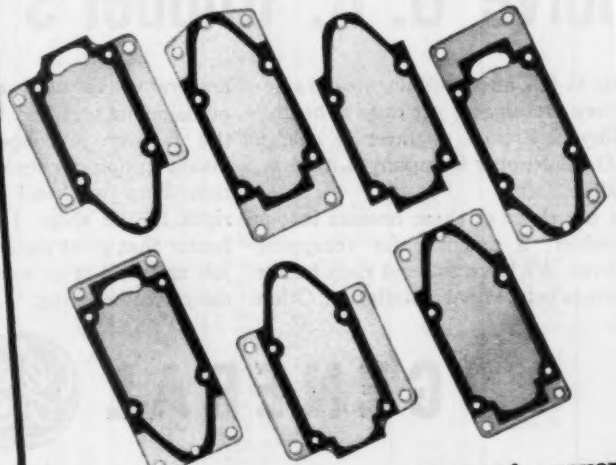


Versatility Plus! Simple adjustment of return spring positioning plate determines position of the movable contact in the "free" position. Equally simple adjustment of latches makes switch either single acting, or double acting with neutral position . . .

11 switches in 1 . . . all you need is a screw driver!

Adjustable! Operating lever arm position is continuously adjustable and provides up to 80° overtravel unless limited by enclosure. An outstanding Square D design feature.

No Inventory Problem! Square D's basic switches and lever arms are separately packaged for your stocking convenience. A moderate stock covers a multitude of possible combinations.



Easy Mounting! Square D provides seven different base plates, plus side mounting holes. It's easy to mount switches in a variety of positions.

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

CALROD TUBULAR HEATERS (see arrow) have been bent *seven times* without breaking, to fit this O. K. Rubber Company Treadwelder. Only Calrod units can take such punishment says O. K.'s Chief Engineer.

Sturdy, Easily Bent G-E Calrod* Heaters Solve O. K. Rubber's Installation Problem

"We use G-E Calrod tubular heaters because they are rugged, yet easy to bend," says Elby E. French, engineer in charge at the O. K. Rubber Company, Littleton, Colorado.

"We use three of these heaters in our Treadwelder, a machine for recapping truck tires. We have to bend each heater seven times before final installation. Other heaters we've used couldn't take this punishment and had to be sent back to the factory and specially bent. This meant shipping costs and delayed production. Now we bend these Calrod units right in the shop. I know of no other heater that gives the heat we need for our job and still is as easy to bend without danger of breaking."

Like O. K. Rubber, solve your design and installation problems with General Electric Calrod heaters. Your nearby G-E Apparatus Sales Office is ready to help you. Call today and write for free bulletin GEC-1005, Calrod Heaters and Heating Devices, Sect. 720-135, General Electric Company, Schenectady 5, N. Y.

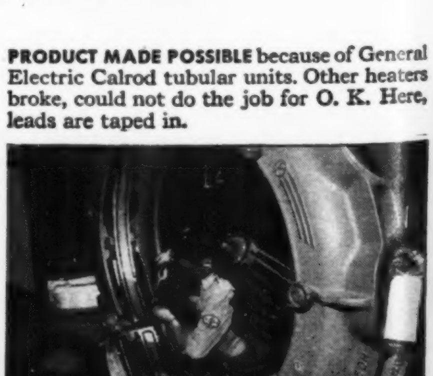
***Reg. trade-mark of the General Electric Company.**

GENERAL ELECTRIC

RUGGED HEATERS ARE EASILY BENT without breaking. Prior to shipment, G.E. anneals heaters in controlled atmosphere furnace to assure safer bending.

HEATERS ARE FITTED to aluminum ring to provide the exact heat required for retreading huge truck tires. Recapping machine is Underwriters' listed.

PRODUCT MADE POSSIBLE because of General Electric Calrod tubular units. Other heaters broke, could not do the job for O. K. Here, leads are taped in.



Augmenting Miller's Quality-Famous Line of "Custom-Built" Cylinders...

Miller *Stock* AIR AND HYDRAULIC CYLINDERS

Available for *Immediate Delivery...*

in the popular sizes, mountings and prices listed below

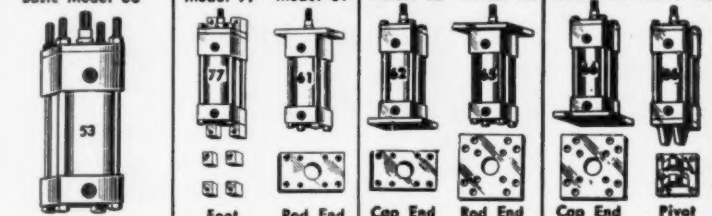
Any of the Interchangeable "Stock" Mountings illustrated are attached by our factory to the "in-stock" Basic Model 53 with the tie rod nuts in a few moments. This gives you a selection of over 500 different "Stock" Cylinders for immediate use—and permits easy conversion to other models for future re-use. Thus, you save delivery and production time, investment cost and storage space. Additional sizes of Stock Cylinders are being added daily, considerably augmenting the list below. Write for complete list.

PRICES OF MILLER "STOCK" CYLINDERS WITH MOUNTINGS ATTACHED AS ILLUSTRATED

(Prices on the separate mounting attachments for future re-use are available on request)

ORDER DIRECTLY FROM THIS LIST . . .

Shipment can be generally made within 24 hours after we receive your order. Prices are F. O. B. our plant.



Tie Rod Mounting · Foot Mounting · Rod End Flange · Cap End Flange · Rod End Flange · Cap End Flange · Pivot Mounting

Bore	Stroke	Cushion	AIR A53	HYD. H53	AIR A61 A77	HYD. H61 H77	AIR A62	HYD. H62 H65	AIR A66	HYD. H66 H86
1½"	2"	Non		$ 58.50		$ 61.40		$ 66.70		$ 72.85
1½"	4"	Non		60.70		63.60		68.90		75.05
1½"	6"	Non		62.90		65.80		71.10		77.25
1½"	8"	Non		65 10		68.00		73.30		79.45
1½"	11"	Non		68.40		71.30		76.60		82.75
2"	2"	Non	$ 37.70		$ 39.75		$ 42.30		$ 44.60	
2"	4"	Non	39.40		41.45		44.00		46.30	
2"	6"	Non	41.10		43.15		45.70		48.00	
2"	8"	Non	42.80		44.85		47.40		49.70	
2"	11"	Non	45.35		47.40		49.95		52.25	
2"	3"	Both	62.05	94.50	64.10	97.45	66.65	103.05	68.95	111.55
2"	5"	Both	63.75	97.00	65.80	99.95	68.35	105.55	70.65	114.05
2"	7"	Both	65.45	99.50	67.50	102.45	70.05	108.05	72.35	116.55
2"	9"	Both	67.15	102.00	69.20	104.95	71.75	110.55	74.05	119.05
2"	13"	Both	70.55	107.00	72.60	109.95	75.15	115.55	77.45	124.05
2½"	2"	Non	41.45	73.30	43.70	76.25	46.25	82.30	49.00	93.10
2½"	4"	Non	43.35	76.00	45.60	78.95	48.15	85.00	50.90	95.80
2½"	6"	Non	45.25	78.70	47.50	81.65	50.05	87.70	52.80	98.50
2½"	8"	Non	47.15	81.40	49.40	84.35	51.95	90.40	54.70	101.20
2½"	11"	Non	50.00	85.45	52.25	88.40	54.80	94.45	57.55	105.25
3¼"	3"	Both	77.80	126.85	80.35	131.20	84.15	138.60	87.70	149.95
3¼"	5"	Both	79.80	129.85	82.35	134.20	86.15	141.60	89.70	152.95
3¼"	7"	Both	81.80	132.85	84.35	137.20	88 15	144.60	91.70	155.95
3¼"	9"	Both	83.80	135.85	86.35	140.20	90.15	147.60	93.70	158.95
3¼"	13"	Both	87.80	141.85	90.35	146.20	94.15	153.60	97.70	164.95
4"	2"	Non	56.25	106.00	59.10	111.15	62.95	118.90	67.30	132.80
4"	4"	Non	58.85	109.40	61.70	114.55	65.55	122.30	69.90	136.20
4"	6"	Non	61.45	112.80	64.30	117.95	68.15	125.70	72.50	139.60
4"	8"	Non	64.05	116.20	66.90	121.35	70.75	129.10	75.10	143.00
4"	11"	Non	67.95	121.30	70.80	126.45	74.65	134.20	79.00	148.10
5"	3"	Both	98.25		101.40		105.25		110.60	
5"	5"	Both	101.65		104.80		108.65		114.00	
5"	7"	Both	105.05		108.20		112.05		117.40	
5"	9"	Both	108.45		111.60		115.45		120.80	
5"	13"	Both	115.25		118 40		122.25		127.60	
6"	2"	Non	80.60		83.95		87.85		94.15	
6"	4"	Non	84.90		88.25		92.15		98.45	
6"	6"	Non	89.20		92.55		96.45		102.75	
6"	8"	Non	93.50		96.85		100.75		107.05	
6"	11"	Non	99.95		103.30		107.20		113.50	
8"	3"	Both	157.35		161.05		167.90		174.95	
8"	5"	Both	162.45		166.15		173.00		180.05	
8"	7"	Both	167.55		171.25		178.10		185.15	
8"	9"	Both	172.65		176.35		183.20		190.25	
8"	13"	Both	182.85		186.55		193.40		200.45	

ler "Stock" Cylinders fully meet the J.I.C. ndards and are identical to Miller "Custom-lt" Cylinders in design and construction.

ock" Air Cylinders are for 200 psi opera-n, "stock" hydraulic cylinders for 2000-3000 operation. Piston Rods of "Stock" Cylinders "Style No. 2 Standard."

complete descriptive and dimensional a on both "Stock" and "Custom-Built" Miller linders, write for Bulletins A-105 and H-104 t FREE on request.

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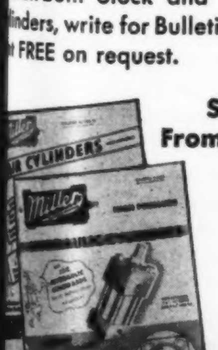

"Stock" Boosters, Too! Immediate delivery on Miller Dual Pressure Boosters; 5" bore, 1" ram (80 psi air input produces 20 psi hydraulic output for driving one or more work cylinders simultaneously). In 6" and 12" strokes. Write for data and pr

mplete Miller "custom-built" line includes: air cylinders, 1½" to " bores, 200 psi operation; low pressure hydraulic cylinders, " to 6" bores for 500 psi operation, 8" to 14" bores for 250 psi eration; high pressure hydraulic cylinders, 1½" to 12" bores, 0-3000 psi operation. All mounting styles available. Also, a plete line of Fluid Pressure Boosters and Accumulators.

MILLER FLUID POWER CO.

(Formerly MILLER MOTOR COMPANY)

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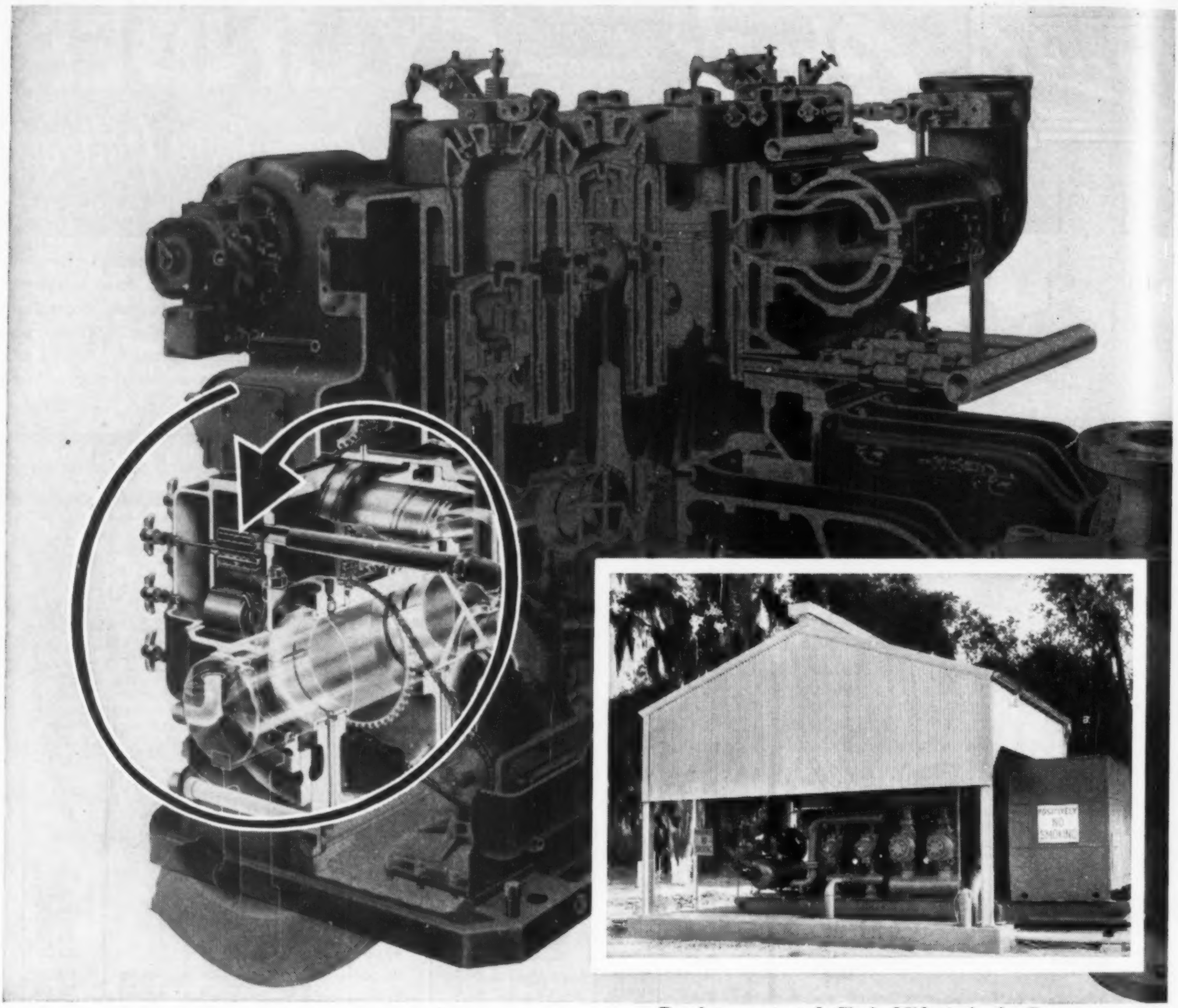

Purolator-protected Clark Midget Angle Compressor, gas-engine-driven. Skid-mounted for portability, Clark Compressor is a favorite for field gas gathering, gas lift, repressuring, flare gas elimination, pipeline testing and recycling plant feeders. Manufactured by Clark Bros., Co., Olean, New York.

Where does the DIRT *belong?*

OUTDOOR ENGINES, like outdoor boys, can't help getting dirty. But dirt will harm neither boys nor engines if steps are taken to get rid of it promptly!

In the Clark Compressor above, Purolator* Metal Edge Filters remove harmful combustion by-products and foreign matter entrapped in air or fuel lines supplying the engine. Purolator Fuel and Lube Filters . . . first line of defense against down time . . . are used on many other well-known "outdoor" engines, too.

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These parts
¼ actual size

How to reduce costs with
HUNTER DOUGLAS

IMPACT FORGING
FROM
HIGH STRENGTH ALUMINUM ALLOYS

The above photo shows a typical size range of closed bottom tubes impact forged by Hunter Douglas from high strength aluminum alloys, 14S-T6 and HD 11. In the three types shown, the finished machined part is adjacent to its corresponding rough impact forging. Obvious graphic proof that minimum machining is required to produce a finished part.

The zero-draft feature of Hunter Douglas eliminates machining the I.D. of the tubes and reduces other machining operations to a minimum. Wall thickness may vary from .050" up to .500" with bases of any required thickness. The flange shown is also optional. Now produced in a single operation, formerly each of these tubes was fabricated from four different parts.

This new technique perfected by Hunter Douglas to mass produce high strength aluminum alloy parts with tolerance of an extrusion and strength of a forging cuts costs and increases production.

If your design demands a tubular shape with or without a closed end for mass production up to a million or more a month, remember the name Hunter Douglas. Our research and development engineers will be pleased to analyze your blue prints or sample parts without cost or obligation.

IMPACT FORGING • STRENGTH OF FORGING • TOLERANCE OF EXTRUSION • H-D

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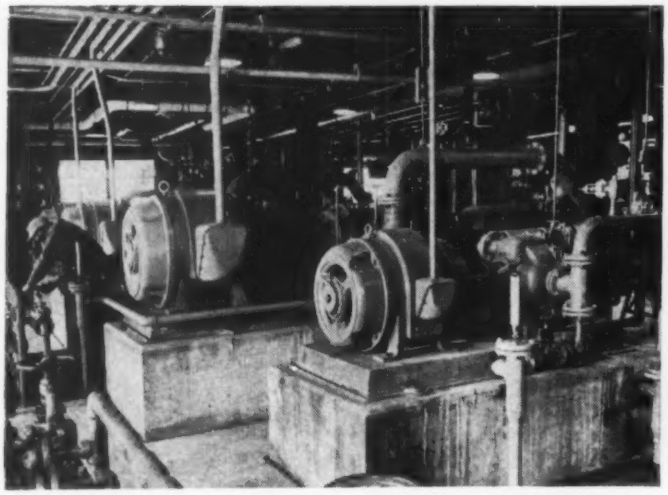
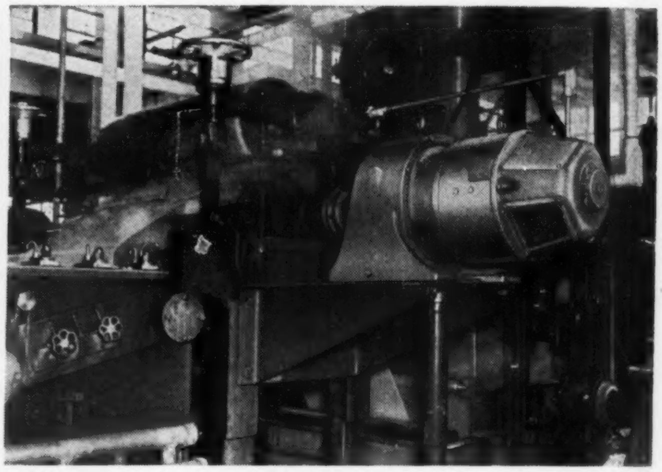
THE Tools of Automation

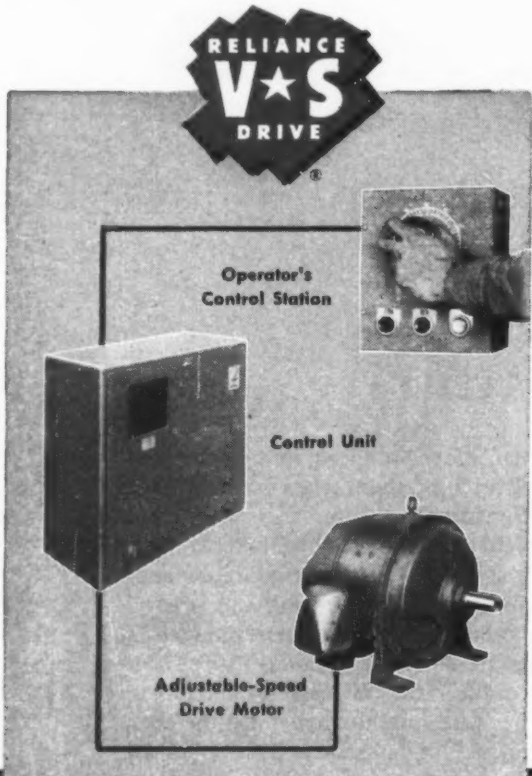
INCREASE PROFITS IN EVERY INDUSTRY



Automation in refineries and the petro-chemical industries is made practical by the choice of the correct Reliance A-c. motors. They provide unfailing power for those processes which go unattended hour after hour.



Fibers and webs of material are processed in the textile, chemical, paper and rubber industries in making the final product. Designed to suit each need, Reliance V★S Drives start, accelerate and control the process speed of these machines so that a continuous flow of usable material is produced.



Greater machinery output . . . improved production efficiency . . . both result in increased profits. And both result from using the Tools of Automation: Reliance electric motors, adjustable-speed drives, electronic controls, and applied engineering. They're setting new standards for low cost production in *every* industry.

These Tools of Automation can most efficiently lower your costs, because they're designed and applied to *your* specific situation. Reliance Application Engineers are backed by nearly 50 years' experience in perfecting the drive systems that can help you attain the degree of automatic production you require. For further information, write for the new booklet, "The Tools of Automation". A-1487-F

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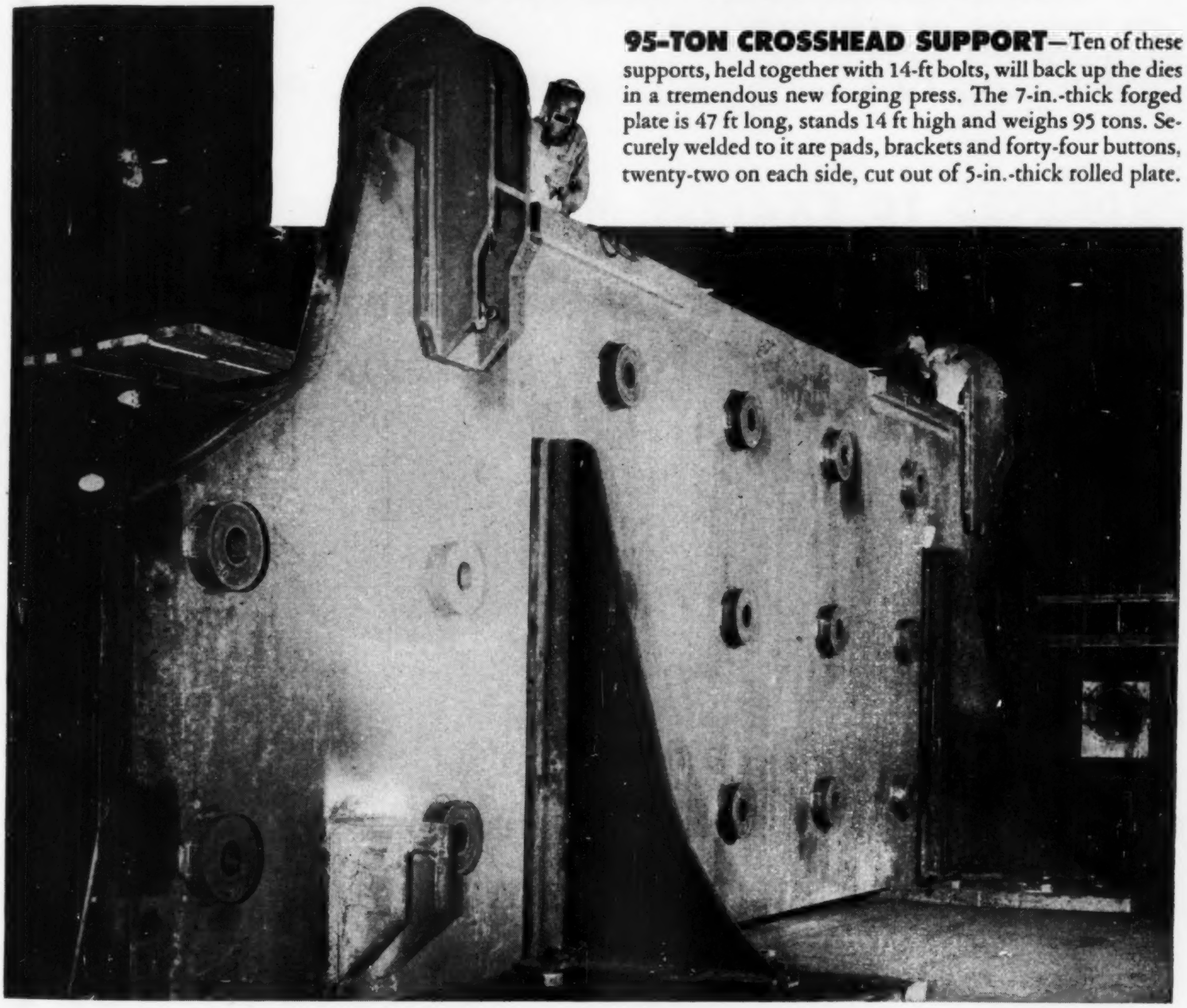
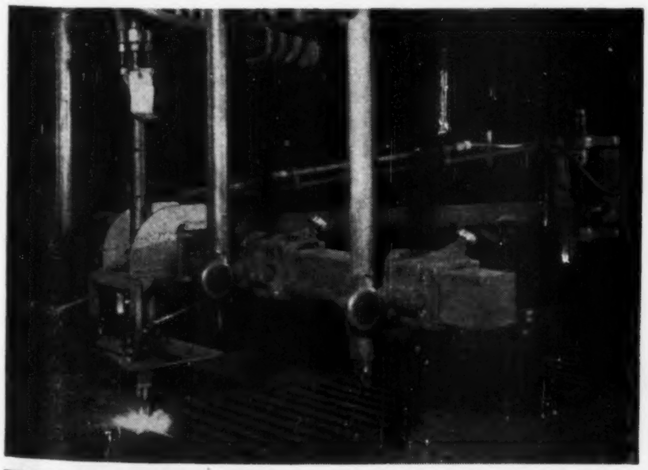
WHAT'S NEW IN WELDMENTS



95-TON CROSSHEAD SUPPORT—Ten of these supports, held together with 14-ft bolts, will back up the dies in a tremendous new forging press. The 7-in.-thick forged plate is 47 ft long, stands 14 ft high and weighs 95 tons. Securely welded to it are pads, brackets and forty-four buttons, twenty-two on each side, cut out of 5-in.-thick rolled plate.



ELECTRONICS HELP IN TRICKY TRACING
Up-to-date burning equipment is at your service in the Bethlehem Weldment Shop. This electronic tracer speeds jobs that require great precision.

WE CAN CUT YOUR "FINGERS"—The equipment shown at the left was used in making this expansion dam for a highway bridge. The tapering fingers were burned down the 44-ft length of a 2-in.-thick rolled steel plate.

BETHLEHEM STEEL

For further information about Bethlehem Weldments, call on the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

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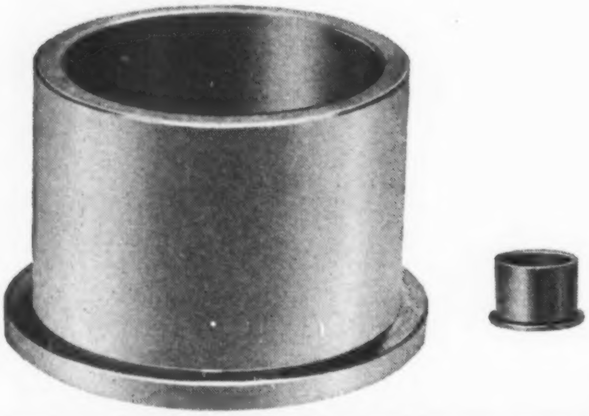
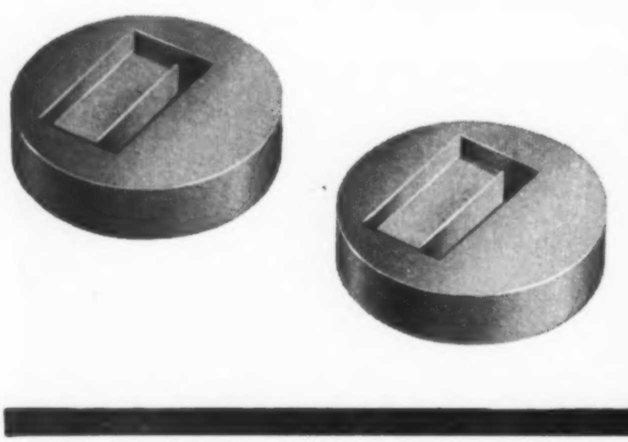
PRODUCED TO EXACTLY MEET ANY REQUIREMENTS

large and small pieces

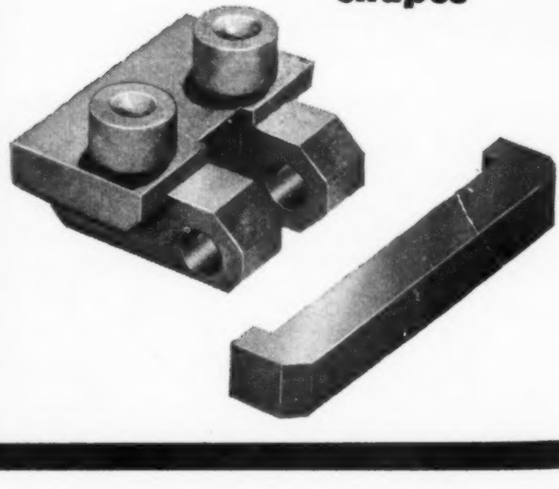


open or close tolerances

single and multiple compositions



simple or complex shapes



104

GRAMIX sintered metal bearings and parts can be produced to meet an extremely wide variety of applications and specifications. Even intricate shapes of close tolerances save considerable money as against similar parts machined from bar stock. With simple compositions and shapes not close in tolerance the costs are amazingly low. In addition our competent engineers will study the prints you submit and recommend the correct composition and design considerations to most practically and economically manufacture your parts. There is no obligation for this service, of course. Write for data book.

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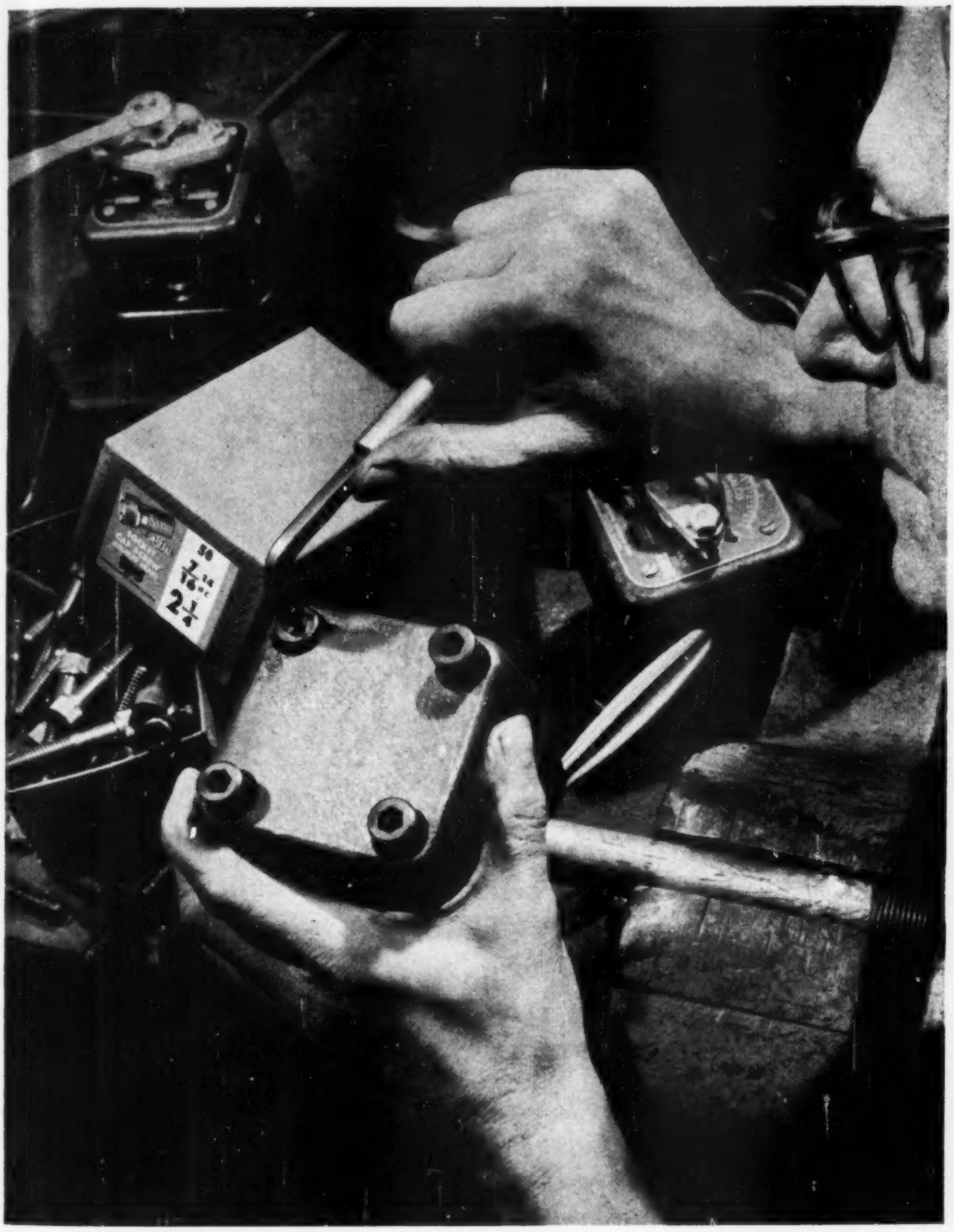

Four UNBRAKO Socket Head Cap Screws speed assembly in the plant, and reassembly in the field, of these flow-control valves providing 16 different inlet-outlet flow direction combinations.

The knurling on the head of the screw permits faster assembly, because it provides a slip-proof grip.

The uniform depth and size of the hex socket assure maximum torque in wrenching. The accurate diameter of the head permits countersinking.

UNBRAKOs—made of heat treated alloy steel—have fully formed threads, Class 3 fit; controlled fillet and continuous grain flow for strength. Supplied in standard sizes from # 4 to 1″.

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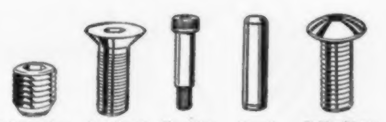
When you use UNBRAKO socket screw products, you get the finest socket screws made, *plus* the personalized service and the faster delivery of your local distributor. And he enables you to cut your inventory, set up more space for production. For more information, write for UNBRAKO Standards—a complete listing of precision socket screw products carried by your distributor. STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

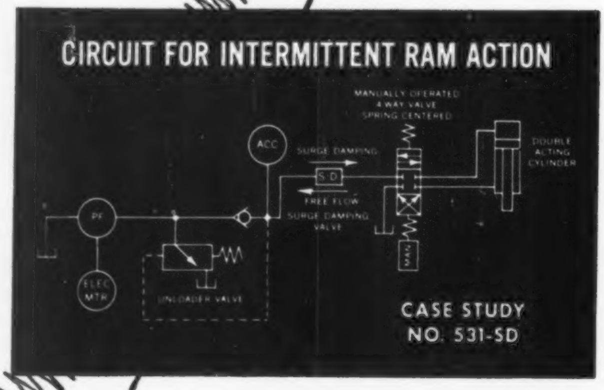
UNBRAKO SOCKET SCREW DIVISION

SPS JENKINTOWN PENNSYLVANIA



Protects hydraulic circuits

ACTUAL SIZE



Denison Surge Damping Valve prevents hydraulic shock... eliminates damage to fittings, lines, seals and equipment

Sudden starting, sudden release of high pressure into a low pressure area, or reversal of flow causes a hydraulic surge as damaging to a circuit as blows from a hammer.

The Denison Surge Damping Valve converts the hydraulic surge into a smooth, gradually accelerated flow of fluid power. A hydraulically unbalanced reaction flow control in the valve causes the valve to open slower as the intensity of the surge increases.

Lightweight and easy to install, the Denison Surge Valve can be used on any circuit up to 5000 psi. Requires no adjustment . . . interferes in no way with the efficiency of the circuit.

The circuit shows a Denison Surge Damping Valve preventing hydraulic shock when stored-up energy in an accumulator is released. For a bulletin on the surge valve, write to: THE DENISON ENGINEERING COMPANY, 1240 Dublin Road, Columbus 16, Ohio.

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THE WEIGHT of this NEW 2HP POWER PRODUCTS INDUSTRIAL ENGINE

then read how SKF helps make it less than you think!

Here's Power Products Corporation's popular 2-cycle engine that delivers 2 horsepower.

How much would you guess it weighs? Fifty pounds? Thirty? Twenty? Guess any of these and you'd be wrong. It weighs just sixteen pounds.

This remarkable power to weight ratio is made possible, in a large measure, through the use of ball bearings at both ends of the crankshaft. Power Products engineers, like many others, recognized the inherent advantages of the 2-cycle principle—lightweight and compactness. The use of ball bearings on the crankshaft enabled them to virtually eliminate radial play with its related problems previously found in 2-cycle engines and produce a dependable small 2-cycle industrial engine.

The application of SKF bearings to this and other Power Products 2-cycle engines helps give the engines longer life, easier starting, consistent operation, as well as accurate timing, hotter spark and less friction which means more power.

SKF Field and Home Office Engineers know a lot of places where anti-friction bearings should be used to make your product better—places where their application produces benefits as it does for Power Products. Any of them, without obligation, will analyze the design of your product and perhaps show you how to make it better. 7959

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manufacturers of SKF and HESS-BRIGHT® bearings.

SKF®
BALL AND ROLLER BEARINGS

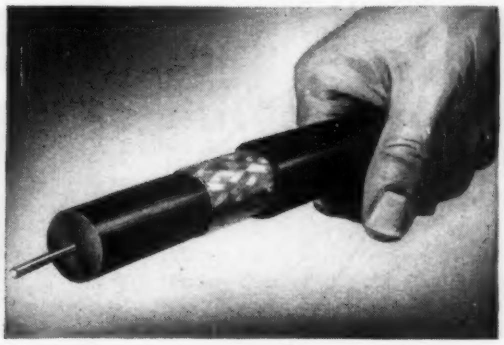
large

55-gallon drums one-piece molded from Bakelite Polyethylene are designed to fit in standard fiber, plywood, or steel overpacks. Chemically inert, they resist acids, caustic soda solutions, electrolytic fluid. Resilient, non-shattering, lightweight, they increase safety, cut shipping costs.

small

Tubes and bottles molded from Bakelite Polyethylene dispense their chemical and pharmaceutical contents when squeezed. Inherently flexible, polyethylene needs no plasticizer. It won't contaminate contents. Tube ends are closed by heat-sealing.

thick



Coaxial cable has thick layer of Bakelite Polyethylene around center conductor and covered by outer conductor. Tough, flexible, and possessing excellent electrical insulating qualities at high frequencies, polyethylene insulates conductors and keeps them correctly spaced. Other extrusions include belts, tapes, tubes, farm water pipe.

or thin

Liquids are being packed in laminations of cellophane or foil with film made from Bakelite Polyethylene. Advantages: added toughness and tear strength, heat-sealing to a strong, watertight bond, and resistance to food and other chemicals.

add a new dimension to product planning—

BAKELITE Polyethylene

TRADE-MARK

Open a new range of performance features for your product. Give it advantages that mean greater sales. Take your pick of fabrication methods—injection molding, extrusion, calendering, coating, vacuum-forming. Bakelite Polyethylene is packed with possibilities—and it's in plentiful supply right now. The first step in your planning is to learn more about it by writing Dept AI-52.

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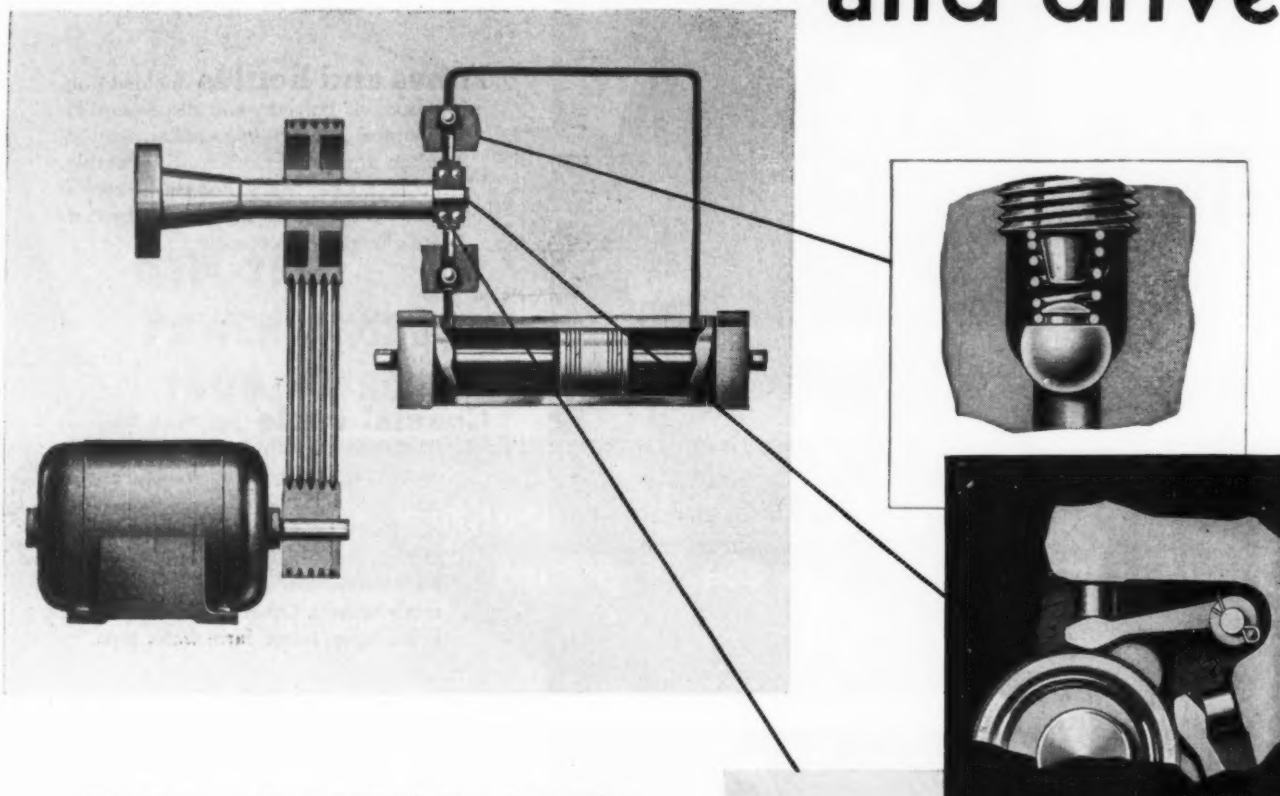
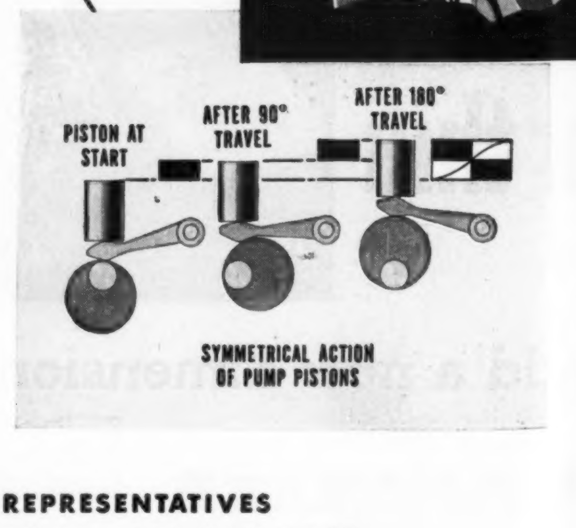
BARNES closed fluid circuit and drive

alone



The Barnes Closed Fluid Circuit consists of a rotary supporting means; a variable displacement pumping arrangement synchronously driven from the rotary means; and a driving arrangement, including means for connecting and disconnecting the rotation of the rotary means, which causes the displacement pump to operate automatically and synchronously with the rotary supporting means.



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DOW CORNING CORPORATION

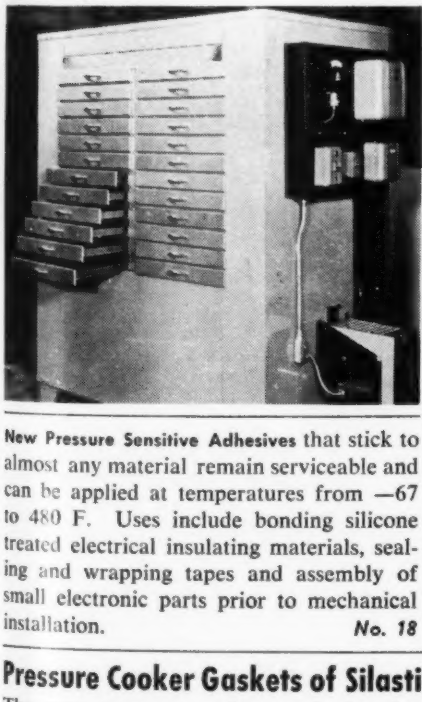
Silicone News

FOR DESIGN ENGINEERS

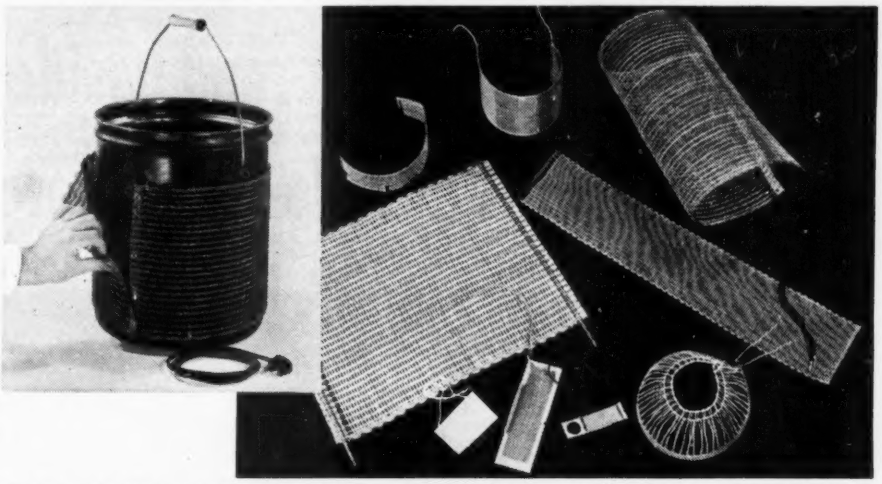
Silicone-Based Paint Withstands Up To 1000 F On Oven Interiors

Especially adapted to preheating and stress relief of small parts, the new Grieve-Hendry cabinet drawer electric oven has a capacity of 850 F. It is so well designed that any one of the 24 drawers may be opened without lowering the temperature of the remaining drawers.

The service life of the oven is increased by finishing the interior of each drawer with a silicone-based aluminum paint formulated by Midland Industrial Finishes of Waukegan, Illinois. Grieve-Hendry has been applying this silicone finish to the interiors of all their oil, gas and electric ovens for over 3 years. Easily applied by spraying to form a smooth and uniform coating, the silicone paint protects the metal surfaces against corrosion at surface temperatures up to 1000 F. *No. 15*



New Pressure Sensitive Adhesives that stick to almost any material remain serviceable and can be applied at temperatures from —67 to 480 F. Uses include bonding silicone treated electrical insulating materials, sealing and wrapping tapes and assembly of small electronic parts prior to mechanical installation. *No. 18*



SILICONE INSULATED WOVEN HEATERS PROVIDE MORE EFFICIENT METHOD OF CONTACT HEATING

Woven contact heaters, once reserved exclusively for the military, are now being offered for a variety of industrial applications. One of these is a 5 gallon drum heater developed by the Pre-Fab Heater Company, Inc., of Guildford, Conn. Designed to melt drums of plastisol, this lightweight heater brings the contents of the drum to temperatures in the range of 110 to 500 F with maximum speed and uniformity. Safe and convenient, the heater snaps in place around the drum and plugs into any 115 volt outlet.

Contact heaters of this type were orginally developed to keep high altitude aerial cameras and control mechanisms operable at sub-zero temperatures. Lighter, less bulky and more flexible than conventional heating pads, the heaters are custom woven to fit the part. Some of the dozens of configurations and patterns developed for military use are shown above. These heaters, operating in the far infra-red range at high efficiencies, carry current-densities of 15 watts per square foot to 15 watts per square inch.

The wires in the heaters designed to meet military specifications, are served with glass yarn impregnated with Dow Corning silicone electrical insulating varnishes to assure long and reliable performance at temperatures in the range of 500 F. The silicone-glass combination eliminates electrical breakdowns caused by sudden and extreme changes in ambient temperatures. It withstands heavy thermal shock without loss of electrical properties.

Another feature of importance to designers is that only slight consideration must be given the heater when designing parts or products requiring this protection. The thin structures are easily tailored to meet specific needs. *No. 16*

Pressure Cooker Gaskets of Silastic Last Longer, Reduce Clean-up Time

The new pressure cooker made by the Hamilton Copper & Brass Works of Cincinnati, features a steam jacket that heats the entire inner bowl. Designed for internal kettle pressures up to 15 psi and steam pressures up to 90 psi, the cookers are sealed with a Silastic* gasket fabricated by Garlock Packing Company.

Tests indicate that the Silastic gaskets will have at least twice the service life of the organic rubber seals previously used. Furthermore, even foods as hard to clean off as tomato paste or candy do not stick to the gasket. Cleaning time is reduced and the carry-over taste associated with organic rubber gaskets eliminated. *No. 17*

Design Edition 4

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HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

. Hydraulic Equipment
Denison Engineering Co.—Multi-range flow ntrol, direct operating pressure control and ot operated check valves are described in strated 4-page bulletin 143-A. Their op-ating characteristics and specifications are ven.

. Diesel Engine Primer
Harnischfeger Corp., Diesel Div.—"What ou Should Know About Diesel Engines" is an teresting 28-page illustrated primer of basic cts. Covering the beginning of the diesel, relates how it differs from a gasoline en-ne, differentiates between two and four-cycle gines and ends up relating the "how-it-orks" details and advantages of the two-cle diesel.

. Air-Actuated Clutch
Twin Disc Clutch Co.—Performance char-cteristics of model PO air-actuated clutch, esigned for application on oil field equipment, anes and shovels, presses and brakes, hoists, c., are related in bulletin 304. Sizes from 14 36 in. are offered with torque capacities to 0,000 lb-ft. Application can be to new or isting equipment.

. Anchoring Machinery Parts
Cerro de Pasco Corp.—"Anchoring Bearing, ushings and Non-Moving Parts in Machinery" technical bulletin making liberal use of hotos and drawings. It describes methods ing various metal alloys that have resulted time and labor savings.

. High Strength Steel
United States Steel Corp.—Carilloy T-1 eel, an engineering material possessing gh yield strength, weldability without pre-ating or stress relief, toughness at subzero mperatures and high resistance to combina-n of impact abuse and abrasion, is subject f 48-page illustrated brochure "United States eel Presents T-1." Extensive technical data, plication information and photos, charts and awings are included.

. Automatic Lubrication
Bijur Lubricating Corp.—Three basic ele-ents of automatic lubrication—lubricators, stribution systems and meter-units—are overed in 4 pages of illustrated "A.B.C. of odern Lubrication." Eight types of lubrica-ors are described and design features of all mponents are given.

7. Speed Reducers
Michigan Tool Co., Cone-Drive Gears Div.—ow standard Cone-Drive shaft mounted speed ducers can be motorized by use of bell hous-g adapters that accommodate standard EMA C-type flanged motors from 1 to 5 hp related in 8-page illustrated bulletin CD-323. echnical details, selection and application ata and dimensioned drawings are included.

. Heat Exchangers
Young Radiator Co.—Material and construc-on features, dimensional drawings and tables ith data on type F fixed tube bundle shell-d-tube heat exchangers are found in 12-page atalog 1254. Guide to heat exchanger selec-on is included.

. Hydraulic Oil Filters
Hilliard Corp.—How the Hilco oil filtration stem for hydraulic systems eliminates con-mination is told in illustrated bulletin F-132. ethods of installation in various types of rcuits are shown in drawings. Range of lter sizes is given.

10. Turbine Pumps
A. O. Smith Corp.—"Turbine Pumps for In-stry" is an 8-page illustrated bulletin which scribes models of vertical turbine pumps. haracteristic curves, details of principal com-onents, application data and discharge head d driver options are discussed.

11. Convoluted Couplings
Solar Aircraft Co.—16-page illustrated cata-log No. 55 on convoluted couplings is a sup-plement to catalog No. 51 on industrial ex-pansion joints and aircraft bellows. Much technical data, specifications for models for ⅛ to 72-in. pipe sizes and formulas for cal-culating various movements are included.

12. Solenoid Contactors
Guardian Electric Mfg. Co.—Wide range of enclosed and sealed models of solenoid con-tactors with power ranges up to 250 amp is described in 8-page illustrated bulletin. Di-mensional drawings, technical data, military specification numbers and other information are included in bulletin SC-9.

13. Gear Motors & Reducers
D. O. James Gear Mfg. Co.—Worm gear motors, for horizontal or vertical drive, with a ratio range from 5.66:1 to 100:1 and from ⅛ to 30 hp are described in catalog 46-C. Horizontal or vertical drive gearmotor reducers in 35 sizes, with 10:1 to 1200:1 ratio range and from ¾ to 75 hp are included in catalog 47-C supplement. Rating tables, dimensions and prices are included.

14. Aluminum Extrusions
Precision Extrusions—Process for producing aluminum extrusions is explained by word and picture in 12-page illustrated brochure. Ad-vantages of the process and the six basic extrusion types are described and illustrated by isometric drawings. Specification table lists physical properties and recommended applica-tions for 14 most-used alloys.

15. Hydraulic Sealing
Plastic & Rubber Products Co.—Types of materials, methods, measurements and speci-fications used by this company's plants in regard to hydraulic sealing problems are re-lated in pictorial brochure 1090.

16. Data Processing Instruments
Consolidated Engineering Corp.—Information on company's line of data-processing equip-ment, which ranges from miniature transducers to entire instrumentation systems, is presented in 12-page illustrated bulletin CEC-1301. Photos, technical specifications and descriptive functional diagrams are included with the con-densed descriptions. Oscillographs, galvanom-eters, amplifiers, power supplies, matching networks, vibration meters and analog-to-digital converters are among subjects covered.

USE THE POSTAGE FREE CARDS BELOW for copies of any-thing listed on this or following helpful literature pages—or for further information on any items in the new parts section or the engineering depart-ment equipment section which you'll find on the next several pages.

For additional information on anything advertised in this issue, use the yellow cards in the front section of this magazine.

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17. Coaxial Cable Connectors

Dage Electric Co.—Cross references and tabbed pages make this comprehensive eight-sectioned catalog 201 on standard and special coaxial cable connectors easy to use. Loose-leaf pages can be added or changed to keep it up to date. Military type numbers are given.

18. Constant Speed Motor

Dalmotor Co.—Type SC-23 motor recommended for continuous duty applications calling for constant speed under varying voltage, load and ambient conditions throughout a wide range of temperature, pressure and humidity variations is subject of 2-page illustrated data sheet. Performance curves are given.

19. Flywheel Couplings

Morse Chain Co.—Morflex industrial engine flywheel flexible coupling units are subject of two illustrated data sheets. They list specifications for standard units that will fit eight Chrysler industrial engine models and 29 Ford industrial engine models. Units include shock-resistant, weatherproof coupling and balanced cast iron adapter plate which bolts to the flywheel.

20. Gasoline Powered Pump

Hypro Engineering, Inc.—Operation and advantages of model G3800 gasoline engine powered pump are described in illustrated catalog sheet. Complete pump and engine, two pump kits for attachment to the user's engine and rubber and roller impeller pumps available are covered.

21. Linear Comparator

Gaertner Scientific Corp.—Reading directly to 0.001-mm and suitable for precise linear measurement of photographic records and spectrographic plates within its range of 150 mm, model M1177 linear comparator is subject of 2-page illustrated data sheet 192-53. Design and operation details are given.

22. Industrial Engines

Chrysler Marine & Industrial Engine Corp.—Chrysler 18 and 19 V-8 industrial engines are described in two respective data sheets with power curves, performance data and specifications. Both engines are available as open or closed power units. The 18, with 241 cu in. displacement and 7.5:1 compression ratio, is rated 37.8 hp A.M.A., while the 19 has 276 cu in. displacement, 7.5:1 compression and is rated 42.05 hp A.M.A.

23. Planetary Gear Transmission

American Gear & Mfg. Co.—From full speed forward to full speed reverse in 1½ seconds is feature of Plan-Gear compound planetary gear transmission. Described and illustrated in 4-page bulletin 3270, transmission has two planetary gear assemblies and a multiple disk clutch for direct drive. Ratings and uses are covered.

24. Cylinders, Collets & Valves

Wellman Engineering Co., Anker-Holth Div.—Rotating and nonrotating air and hydraulic power cylinders. Air-Grip chucks and collets and air valves of Anker-Holth manufacture are described and illustrated in 4-page bulletin. Abridged specifications are presented.

25. Panel Instruments

DeJur-Amsco Corp.—Model 150 waterproof, miniature panel instruments specified in data sheet include dc microammeters, ammeters, milliammeters, voltmeters and ac voltmeters. Instruments utilize miniaturized external pivot D'Arsonval movement for maximum accuracy and stability of adjustment.

26. Coolant & Lubricant Pumps

Pioneer Pump & Mfg. Co.—Pioneer and Rollway coolant and lubricant pumps are pictured in various machine installations in 8-page brochure. Former operate with an impeller, while latter are positive displacement type that operate with rolling motion.

27. Socket Screw Products

Standard Pressed Steel Co.—32-page catalog "Unbrako Standards" on socket screw products covers socket head cap screws, self-locking set screws, shoulder screws, flat head socket cap screws and button head socket screws. Also illustrated and specified are square head set screws, Dryseal thread pressure plugs, precision ground dowel pins and socket screw keys.

28. Applying Plastisol Coatings

Bakelite Co.—Technique for applying plastisol coatings on wire, goods, paper, fabric, foil and electrical assemblies is presented in 36-page booklet on Bakelite vinyl dispersion resin QYNV. Plastisols provide oil and chemical-resistant coating, baked on most materials without need for expensive equipment or costly solvents.

29. Vulcanized Fiber Products

Spaulding Fibre Co.—36-page booklet on "Spaulding Products for Industry" provides detailed list of general physical properties and specific uses for these products, plus engineering reference data. Covered are vulcanized fiber in sheets, rods, tubes and fabricated parts; Armite thin insulation; Spauldite laminated thermosetting plastic, in sheet, rods, etc.; Spauldo motor insulation; fiber board in sheets and parts; transformer board; and materials handling equipment.

30. Porous Bronze Bearings

Bound Brook Oil-less Bearing Co.—More than 600 of most widely used sizes of oil-retaining porous bronze bearings are listed by size in 20-page "Compo Stock List No. 4." These include flange, sleeve and thrust bearings, together with cored and solid bar stock. Bearings are vacuum impregnated with as high as 25 per cent by volume of oil.

31. Polymer/Epoxy Adhesives

Thiokol Chemical Corp.—"Thiokol Liquid Polymer/Epoxy Adhesives" is title of 16-page booklet which reviews the advantages, formulation, properties and other data relative to these adhesives. Surface preparations for aluminum and glass, rubber, steel, copper alloys, plastics and wood are given. Adhesives can be cured at any temperature up to 250° F, with only contact pressure required.

32. Bearing Grease

Alpha Corp.—Ten advantages of Molykote type BR-2 multipurpose, extreme pressure lubricant are pointed up in bulletin 101. Lubricant is particularly suitable for use in highly-loaded ball and roller bearings and on heavily-loaded sliding friction surfaces. Operating temperature range is —30 to 350° F.

33. Rubber & Leather Packings

E. F. Houghton & Co.—Six technical bulletins, each featuring essential data and standard sizes on individual types of packings, are now available. Three cover Vix-Syn rubber O-ring packings and gaskets, V's and U-cups, while other three describe VIM leather V's, U's and leather cups.

34. Wires & Cables

Chester Cable Corp.—Construction of 24 different wires and cables for the radio, electronic and television industries is illustrated along with brief description of their individual uses in 6-page folder. Cables and wires feature highly pliable Plasticord and Plasticote insulations.

35. Industrial Plastic

Westinghouse Electric Corp.—52-page catalog B-5878 on Micarta industrial plastic is actually a handbook of technical information prepared for the designer and user of industrial materials. Catalog covers all grades and forms in which Micarta is supplied and the chemical, mechanical and electrical properties of each. Product resists compression, impact, corrosion and moisture and can be used in temperature range from —112 to 392° F.

36. Super Alloys

Universal-Cyclops Steel Corp. — Physical properties and processing data on "Super Alloys" is given in 20-page brochure. These high strength heat and corrosion-resistant materials are used for critical parts of jet

(*Continued on Page* 244)

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DU PONT

NEWS

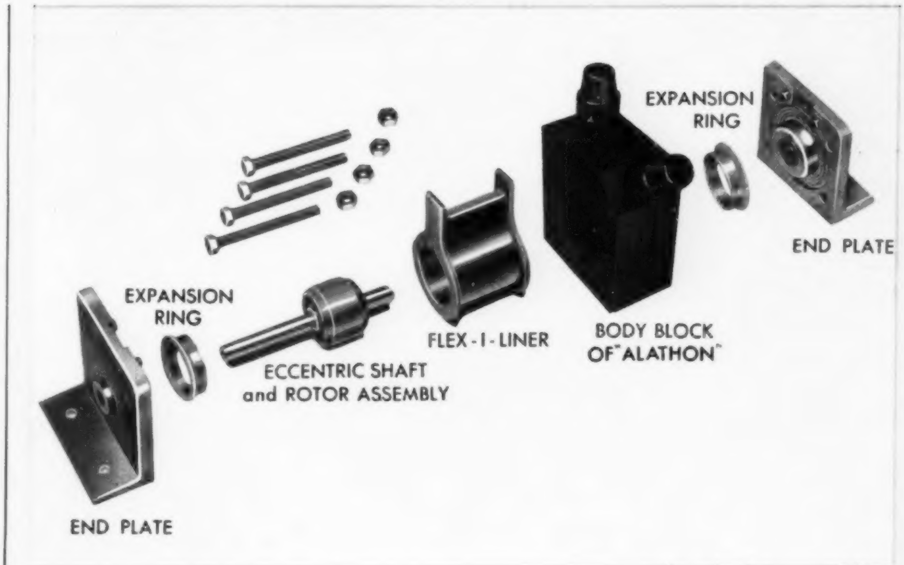
PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NO. 9 — 1954

New Pump Using Du Pont ALATHON® Needs No Stuffing Boxes, Shaft Seals, or Check Valves

"Alathon" resists corrosive fluids, abrasive slurries

THE patented "Flex-i-liner" pump shown at the right features a body block of molded Du Pont "Alathon" polyethylene resin. It is designed to handle such industrial fluids as acids, alkalies, solvents, biological solutions and food products. Corrosion and contamination are eliminated because "Alathon" is resistant to chemical attack.



"Flex-i-liner" pump, manufactured by Vanton Pump & Equipment Corporation, New York City, is shown above in an exploded view. Corrosion and contamination problems are avoided with this pump—thanks to a body block of corrosion-resistant Du Pont "Alathon" polyethylene resin, molded in one piece.

Fewer Parts

Vanton Pump & Equipment Corporation has designed a pump with fewer parts and high efficiency. Stuffing boxes and shaft seals are eliminated, so external leakage is avoided. The pump is self-priming, needs no check valves and gaskets. Process industries can use the "Flex-i-liner" for a wide range of applications. The body block of "Alathon" will resist concentrated hydrochloric, sulfuric and hydrofluoric acids, some oxidizing agents and caustics. It also stands up well against abrasive slurries.

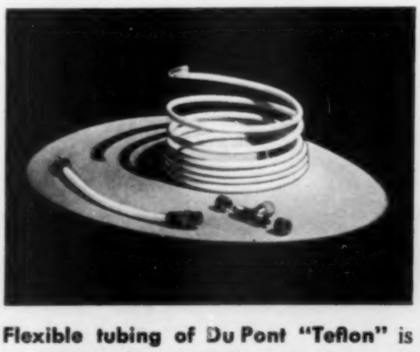
Other Properties

Du Pont "Alathon" has properties which can help solve a wide variety of design and operating problems. The lightness, toughness, corrosion-resistance, good dielectric properties, and easy moldability of "Alathon" are important advantages for the design engineer to consider. For more information about "Alathon" fill out and mail the coupon on the reverse side.

OVER

Thinwall tubing of Du Pont TEFLON® makes assembly easier

EXTRUDED thinwall tubings of Du Pont "Teflon" tetrafluoroethylene resin are easy to handle—they can be cut with a knife, and bent by hand. Because "Teflon" has a smooth, wax-like surface, the tubing slips into position easily. The chemical inertness, resistance to heat and cold, strength, and excellent dielectric properties of "Teflon" make this tubing useful for a wide range of electrical and chemical applications.



Flexible tubing of Du Pont "Teflon" is manufactured by the Halogen Insulator and Seal Corp., Franklin Park, Ill. This tubing is lightweight, chemically inert, has excellent dielectric properties, and a working temperature range of −450°F to 500°F.

DU PONT REG. U.S. PAT. OFF.

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NO. 9 — 1954

Bearings of TEFLON® are self-lubricating

DESIGN engineers have a unique bearing material in Du Pont "Teflon" tetrafluoroethylene resin. "Teflon" is self-lubricating, any friction produced being no more than that of ice against ice.

The coefficient of friction of "Teflon" stays constant through load changes and temperatures up to 620°F. It has zero water absorption—won't shrink, swell, crack or harden. Mechanically strong, "Teflon" has good impact strength and abrasion-resistance under normal conditions of speed and load.

For more information about this versatile engineering material, its use for bearings, and their applications, mail the coupon below.

Investigate Du Pont engineering materials in your product development programs

ONE OF the family of these versatile engineering materials is often a key factor in product improvement or new product design.

The wide range of properties available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and "Zytel"† nylon resin are helping solve industrial design problems.

NEED MORE INFORMATION?

CLIP THE COUPON for additional data on the properties and applications of these Du Pont engineering materials.

Coil assembly of "Zytel" resists high surge voltage

DU PONT "Zytel" was chosen by General Electric to encapsulate the motor coil in their combination watthour meter and time switch. "Zytel" nylon resin protects the motor coil from a 7000 volt 60 cycle and a 10,000 volt surge to ground. It withstands severe shock, cycling between 100°C. and −40°C. The encapsulation is accomplished by a relatively simple molding cycle, rapidly and economically. The corrosion resistance, compactness, and attractive appearance of "Zytel" nylon resin are other important reasons for specifying this engineering material.

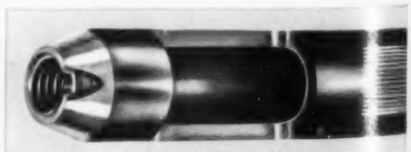
Motor coil for General Electric watthour meter is encapsulated with Du Pont "Zytel" nylon resin. Encapsulation is accomplished by rapid injection molding.

Du Pont "Zytel" nylon resin is a valuable material for the design engineer. Its lightness of weight, abrasion-resistance, and dimensional stability, as well as the dielectric properties of "Zytel," are being used in a wide variety of applications. Use the coupon at the bottom of the page for complete property data on this unique engineering material.

Unique lighter is molded of tough, transparent LUCITE®

A GLANCE will tell if you need fluid or flints for this attractive lighter molded of transparent Du Pont "Lucite" acrylic resin. "Lucite" is injection-molded to provide the body. Articles of "Lucite" such as this lighter can be molded economically in a wide variety of transparent, translucent and opaque colors.

A lighter you can see through! It's molded from Du Pont "Lucite" acrylic resin. Manufactured by the Santay Corporation, Chicago, Illinois.



"Production costs reduced"—that's the report of the Heli-Coil Corp., Danbury, Connecticut, now that they've switched to molded Du Pont "Zytel" nylon resin for their pre-winder tool. This tool, used to screw corrosion-resistant, precision thread inserts into tapped holes, is 75% lighter because of "Zytel". The tough, abrasion-resistant threads of "Zytel" wear twice as long as the material previously used.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 1212, Du Pont Building, Wilmington 98, Delaware.

Please send me more information on the Du Pont engineering materials checked: ☐ "Zytel"; ☐ "Alathon"; ☐ "Teflon"; ☐ "Lucite". I am interested in evaluating these materials for:

NAME ____________ POSITION ____________

COMPANY ____________

STREET ____________

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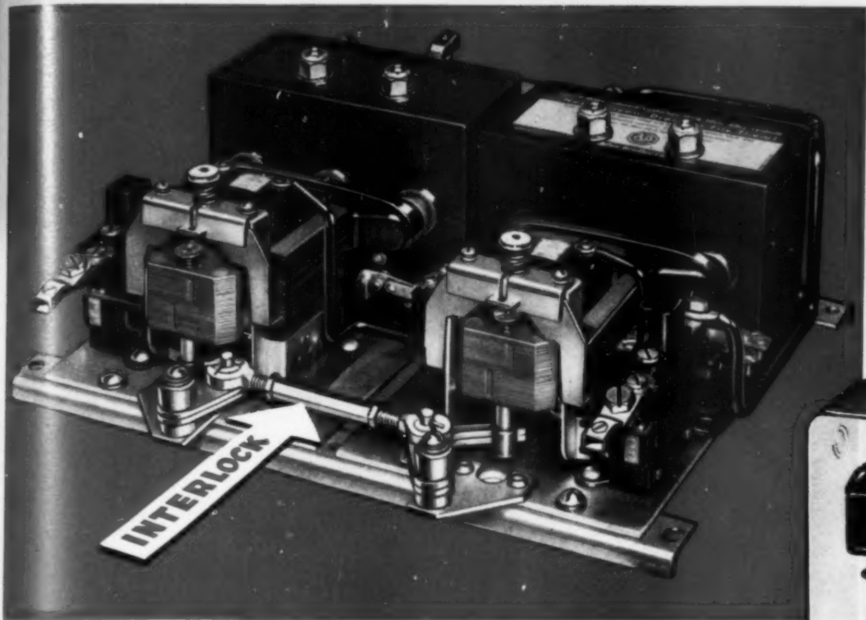
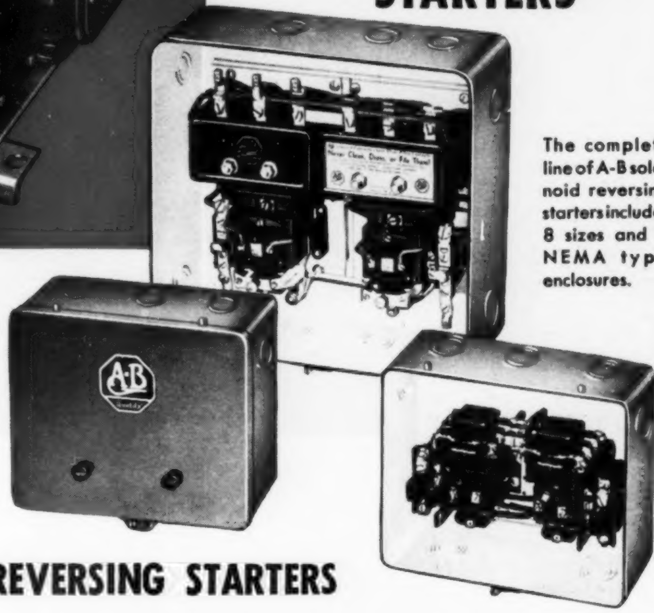
*"Alathon", "Lucite", "Teflon" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)
†"Zytel" is the new trade-mark for Du Pont nylon resin.



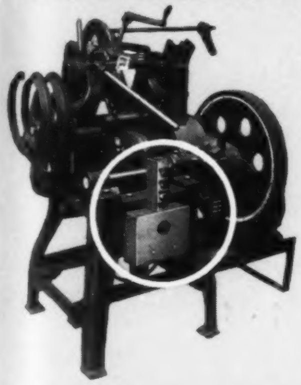
Allen-Bradley reversing starters have two solenoid contactors—FORWARD and REVERSE—which are mechanically, as well as electrically, interlocked to provide maximum safety for motor and machine.

BULLETIN 705 REVERSING ACROSS-THE-LINE STARTERS

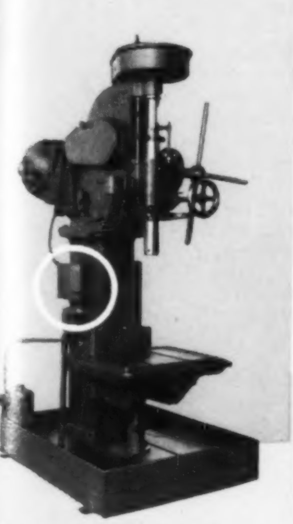


The complete line of A-B solenoid reversing starters includes 8 sizes and 5 NEMA type enclosures.

TYPICAL APPLICATIONS



Excelsior Circular Bending Machine with A-B reversing starter and 3-button control.



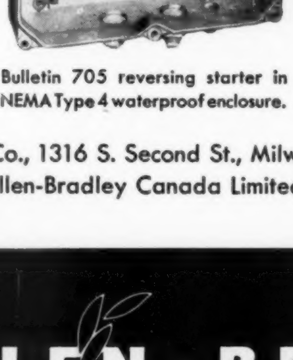
Baker Heavy Duty Drilling Machine with A-B reversing starter in NEMA 1 enclosure.

TROUBLE FREE REVERSING STARTERS

...... up to 300 HP, 220 V; 600 HP, 440-550V.

For squirrel-cage or slip-ring motors that must be reversed in their operation, the most dependable control is the Bulletin 705 reversing starter. The two Allen-Bradley solenoid switches ... with their double break, silver alloy contacts ... are maintenance free. Their rugged construction makes them especially suitable for plugging operations. The contacts will not weld or flash over, and they require no cleaning, filing, or dressing.

Bulletin 706 combination reversing starters are equipped with manual disconnect switches, with or without fuses. Bulletin 707 combination reversing starters have circuit breakers. Allen-Bradley reversing starters are available with or without overload relays. Listed as standard in enclosures for general purpose, watertight, weatherproof, and hazardous dust and fume locations. Write for A-B Handy Catalog, today.



Bulletin 705 reversing starter in NEMA Type 4 waterproof enclosure.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Limited—Galt, Ont.

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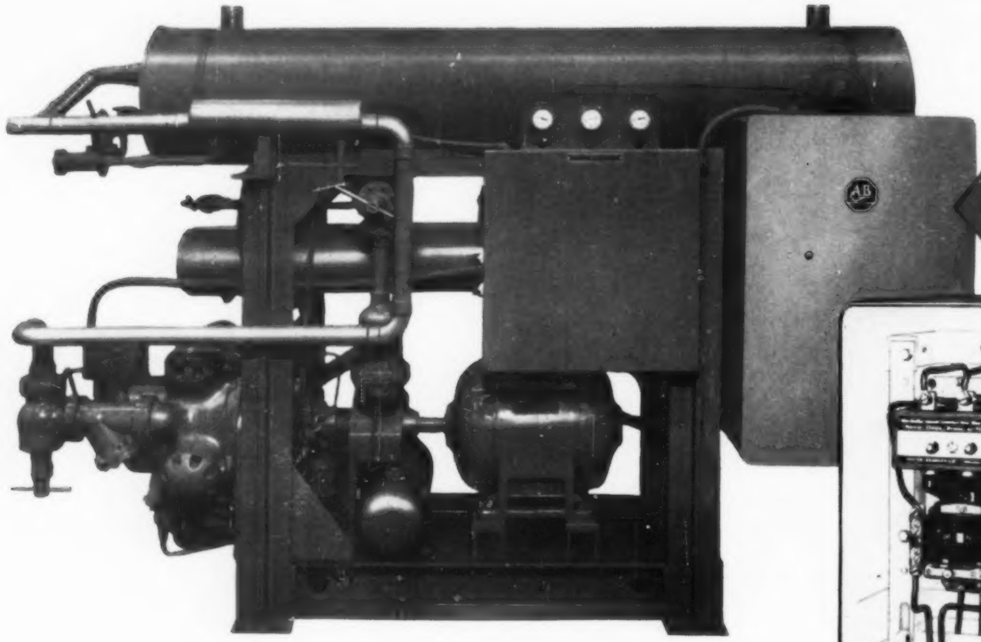
A-B Quality

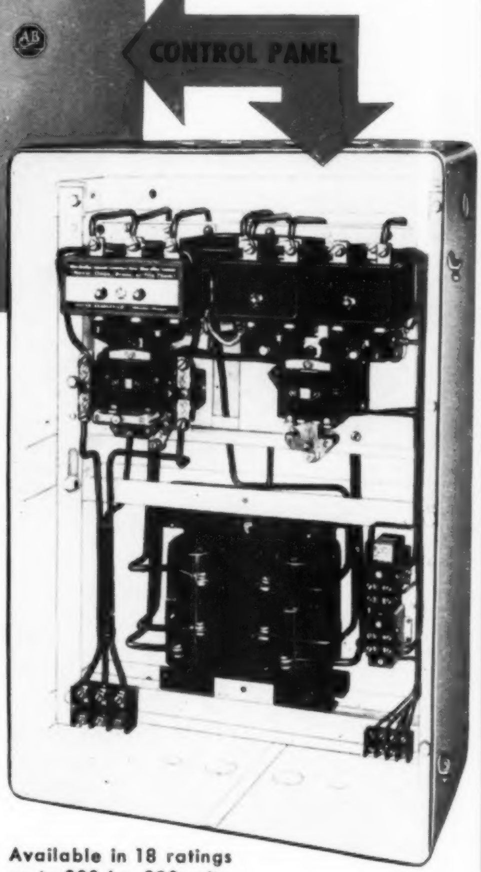
ALLEN-BRADLEY

BULLETIN 705 REVERSING SWITCHES

QUALITY



Close-up of Bulletin 746 automatic reduced voltage starter, showing the START and the RUN contactors and the autotransformer with the reduced voltage taps.



AUTOMATIC REDUCED VOLTAGE STARTERS for Air-conditioning Compressors...

This Airtemp Water Chiller provides a refrigerated coolant that is circulated to room coolers throughout an air-conditioned building. The starting current of the 25 hp squirrel cage motor would cause a noticeable voltage dip, if an across-the-line starter were used. Therefore, Airtemp uses an Allen-Bradley Bulletin 746 autotransformer reduced voltage starter, knowing that it will satisfy power company regulations. Two relays protect the motor against sustained overloads. For the complete story, send for Bulletin 746.

Available in 18 ratings up to 300 hp, 220 volts; 600 hp, 440-550 volts.

QUALITY COMPONENTS OF ALLEN-BRADLEY BULLETIN 746 AUTOMATIC AUTOTRANSFORMER STARTERS

SOLENOID STARTER

The basic unit of the Bulletin 746 reduced voltage starter is the Bulletin 709 solenoid switch with double break, silver alloy contacts that are maintenance free. They are good for millions of trouble free "starts."

TAPPED AUTOTRANSFORMER

Right — Autotransformer with 50, 65, and 80% taps.

TIMING RELAY

Right—Bulletin 849 pneumatic adjustable timer which controls the time interval between closing of the "start" contactor and closing of the "run" contactor. It automatically disconnects the autotransformer and closes the running contactor for full voltage on the squirrel-cage motor.

10—54

Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Limited
Galt, Ont.

A-B Quality

ALLEN-BRADLEY
QUALITY

Announcing a versatile new line of reducers

CONE-DRIVE SHAFT MOUNTED SPEED REDUCERS

Now, designers can take advantage of the unique double-enveloping worm gear design of Cone-Drive gears in shaft mounted speed reducers. The right angle between input and output shafts offers many application and space-saving advantages over conventional gearing. The reducers are mounted directly on the driven shaft and require only a simple bracket or torque arm to prevent rotation of the reducer.

The new reducers can be readily motorized, if desired. A bell housing is available to accommodate standard NEMA C-type flanged motors. Expensive couplings are not required since a tang-type drive sleeve and suitably machined worm are provided with the bell housing to match the motor shaft being used.

Standard reduction ratios range from 5:1 to 60:1. When the motor is connected to the input shaft by means of vee-belts or pulleys, additional speed reduction can be easily obtained. Bore sizes are available to accommodate shafts from 1″ to 2½″ in steps of 1/16″. All sizes are available from stock.

Complete engineering details are available in Bulletin CD-323. It's free for the asking.

MORE HP PER POUND • MORE HP PER CUBIC INCH • MORE HP PER DOLLAR

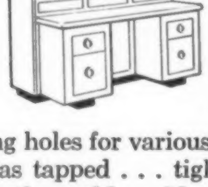
CONE-DRIVE GEARS *Division, Michigan Tool Company*

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

7171 E. McNichols Road • Detroit 12, Michigan

FASTEST THING IN FASTENINGS®

SPEED NUTS® "build in" 30% savings on enclosure system



● Here's how the Elgin Metalformers Corporation, Elgin, Illinois, reduced the total cost of its EMCOR control equipment enclosures by 30%!

The basic EMCOR console requires 276 mounting holes for various assembly arrangements. Formerly, each hole was tapped . . . tight tolerances and paint clogging presented a costly problem. Now, the use of 40 "J" Type SPEED NUTS makes it unnecessary to tap the holes. SPEED NUTS provide the right amount of float, eliminate the problem of paint clogging, and furnish an attachment $3\frac{1}{2}$ times stronger than the former fastening method. And they can be easily moved from hole to hole, wherever attachments are to be made.

In other applications, SPEED NUTS replaced 48 weld-type fasteners to help gain a substantial saving in assembly space as well as the over-all saving in production costs!

Ask your Tinnerman representative for data on better, more economical fastening methods for your own products!

"J" TYPE SPEED NUTS

These standard Tinnerman fasteners snap over panel edges by hand. They are self-retaining in center hole locations providing quick, easy fastenings even in blind assemblies. A full range of panel thicknesses and screw sizes are available to meet your particular requirements.

Write today for your "SPEED NUT Savings Stories" booklet of typical Tinnerman savings to industry: TINNERMAN PRODUCTS, INC., Box 6688, Dept. 12, Cleveland 1, Ohio.

In Canada: Dominion Fasteners Ltd., Hamilton, Ontario. *In Great Britain:* Simmonds Aerocessories, Limited, Treforest, Wales. *In France:* Aerocessoires Simmonds. S. A.—7 rue Henri Barbusse, Levallois (Seine).

'54 Forecast: MORE ALUMINUM PRODUCTS THAN EVER BEFORE

Reynolds ALUMINUM REPORTER

MODERN DESIGN HAS ALUMINUM IN MIND

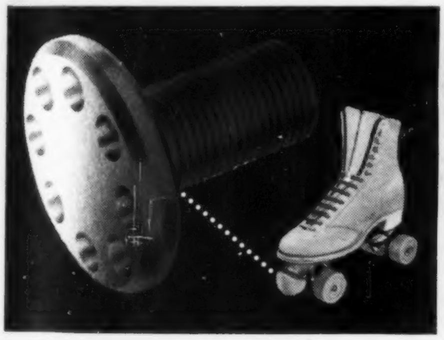
★ ★ ★ Sixteenth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

ALUMINUM IMPROVED AS ELECTRICAL CONDUCTOR

Aluminum Screw Machine Skate Part Has Strength Without Weight

The skate toe stop shown below is made by Ware Brothers Division of Chicago Roller Skate Company. Reynolds 2011-T3 aluminum screw machine stock was selected for the part because it offers ample strength and mass yet is light in weight. This manufacturer of quality skates also uses a forged aluminum foot plate for the same strength to weight advantage.

Job for job, aluminum alloys machine at greater speeds and feeds, thus stepping up production. Unit costs for material, handling and shipping step down because of aluminum's light weight with strength.



For help on alloy selection and prompt delivery on aluminum screw machine stock call your Reynolds Office or Distributor listed under "Aluminum" in your classified telephone directory. Write on business letterhead for your free copy of the 124-page handbook, "Machining Aluminum Alloys." Address Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

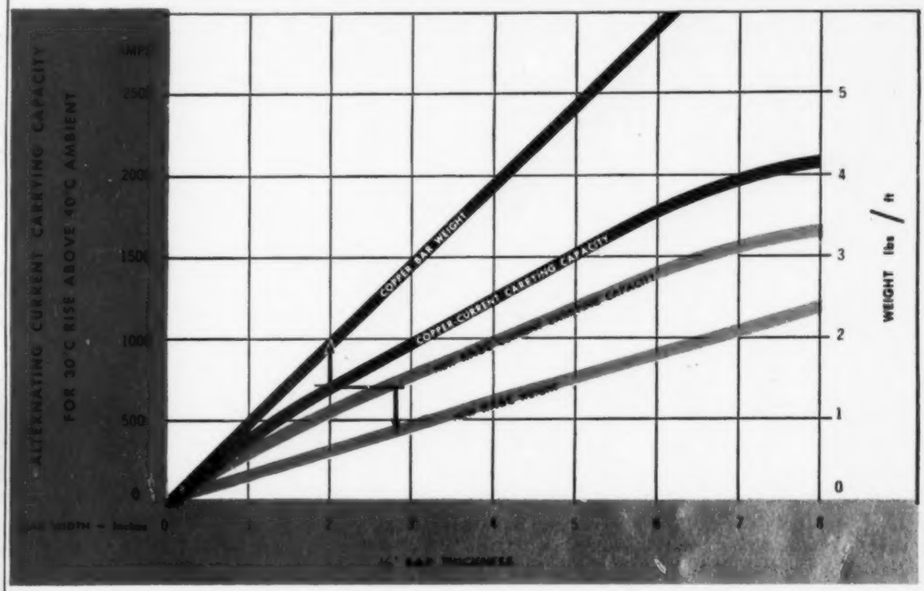
Aluminum Industry Adopts New Alloy Designation System

The Aluminum Association has developed a new system of wrought aluminum alloy designations to supplant various systems previously used. The new system which overcomes inadequacies of the old systems became effective on October first.

To speed transition from the old to the new standard designations the Reynolds Metals Company is offering a simplified conversion chart. Two sizes of the chart are available, one 17" x 22" is read easily when wall hung, the other is 8½" x 11" for use at desk or drawing board. Both old to new and new to old conversions are shown.

Write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky for your free copy of either size chart.

Reynolds Aluminum Development Increases Bus Conductor Strength; Maintains High Conductivity



A new Reynolds development, especially for bus conductor applications, provides greater strength with very little effect on electrical conductivity. An example from the chart above shows why this new material is just what the electrical industry ordered. A current load of 700 amperes requires a copper bar 2" x ¼" weighing just under 2 pounds per foot; new RABC (Reynolds Aluminum Bus Conductor) carries the same load with a 2.8" x ¼" bar weighing only 4/5 pound per foot. The result is a 60% saving in weight.

New Flexibility in Sizes and Shapes

In addition to providing greater strength advantages RABC is available in an unlimited range of sizes and shapes that permit designing to the minimum amount of metal needed for the current carrying job. It is no longer necessary to specify oversize conductors because of intermediate size limitations. The result is a material cost as low as or lower than for any previous aluminum bus conductor.

Many Cost Advantages

All of the basic advantages of aluminum bus conductor, of course, still hold true. More conductivity per dollar. Long range availability. Excellent resistance to corrosion. And, lighter weight which permits faster, easier handling and saves on installation time and labor costs.

ALUMINUM vs. COPPER BUS CONDUCTOR MATERIALS

PROPERTIES	COPPER	ALUMINUM EC-H17	ALUMINUM RABC
Tensile Strength (psi)	33,000 to 37,500	17,000	29,000*
Yield Strength (psi)	Not Specified	15,000	25,000*
Electrical Conductivity % IACS	98%	61%	55%*
Current Carrying Capacity†	100%	82%	79%
Resistivity @ 20°C (microhms, sq in./ft)	8.31	13.36	14.82
Modulus of Elasticity (lb/in.²)	16 x 10^6	10 x 10^6	10 x 10^6
Density (lb/in.³)	.322	.09765	.09765
Temp. Coeff. of Resistance (% per °C @ 20°C)	.393	.403	.360

*Guaranteed minimum. †For given temperature rise and same cross section

Send for new descriptive literature on Reynolds Aluminum Bus Conductor and an index of other Reynolds Literature. Write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Kentucky.

300,000 Volts Plus Is Normal Load for Big Reynolds ACSR

Reynolds Metals Company recently fabricated a special order of Aluminum Cable Steel Reinforced (ACSR) as large as any cable yet made for overhead service in this country. This cable has an outside diameter of 1.76 inches and will be used in a 300,000 volt power system. This is a dramatic example of the advantages resulting from the light weight and electrical conductivity of Reynolds Aluminum.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

(Advertisement)

Printed in U.S.A.

(Continued From Preceding Page)

Fluted Aluminum Tubing Ideal for Decorative Applications

Exceptionally beautiful effects in the construction of furniture and architectural decoration are being obtained through the use of tubular, fluted extrusions of 6063-T6 Reynolds Aluminum. They can also be used in making outdoor clothes driers and poles, umbrella and vacuum cleaner handles, display racks, clothes trees, ladder rungs and many other useful items. Ladder rungs of this material, for example, have a safer, nonslipping surface.

The new fluted aluminum tubing has an ultimate strength of 32,000 psi, a yield of 25,000 psi and 8% elongation. Data on standard sizes are given below.

Standard Tube Sizes*	Nominal Weight lb/100 ft	Minimum Inside Bend Radii: Machine Bending With Mandrel	Minimum Inside Bend Radii: Machine Bending Without Mandrel
¾" x .050" Wall	12.7	1 13/16"	1⅝"
⅞" x .050" Wall	13.7	2 7/16"	2 3/16"
1" x .050" Wall	16.0	3⅛"	2 13/16"
1" x .0625" Wall	20.0	2⅝"	2 1/16"

*Other sizes available on special inquiry

Smooth surface drawn aluminum furniture tubing for other than fluted finishes, of course, continues to be available in 6063-T831 and 6063-T832 alloys and tempers, in ¾", ⅞" and 1" sizes, with .049" through .065" wall thicknesses. For more complete information write Reynolds Metals Company, 2576 South Third St., Louisville 1, Kentucky.

Reynolds New Master Alloy Aluminum Pigs Cut Foundry Costs

A new concept of reduction pot practices has resulted in the production of two new master alloy aluminum pigs at regular pig prices.

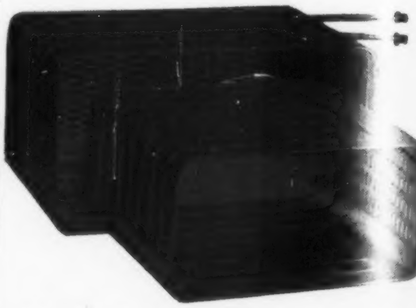
Both new pigs, designated as 2364 and 2393, have been added to the full line offered by the Reynolds Metals Company. Their use in foundries provides improved production control and fewer rejected castings.

Available in the 50 pound size, these new master alloy pigs provide more uniform analysis through simple blending with secondary metals to control undesirable impurities.

Chemical analysis of 2364 alloy pig is silicon 6%, copper 4%, nominal iron and balance aluminum. 2393 alloy pig has a chemical analysis of silicon 9%, copper 3½%, iron ¾%, balance aluminum. Complete information on these and the family of aluminum pig and ingot products by Reynolds is available from the Reynolds office or Pig and Ingot Distributor listed under "Aluminum" in your classified telephone directory. Or write direct.

Roll Bonded Aluminum Sheet Now Produced by Reynolds for Refrigeration Industry

Reynolds roll bonded aluminum sheet is two sheets of aluminum metallurgically bonded together. It is an ideal material for refrigerator evaporators, freezer liners and freezer cold plates. In fact, it should be an economical, efficient and practical replacement for all applications involving heat exchanging where tubing fastened to sheet has been used in the past.



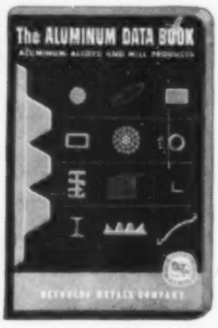
Metal ordinarily used for tubing, accumulators and receivers is eliminated. The passageways are inside the sheet. There are no tubes to bend. Welding is minimized. There is no brazing and therefore no flux contamination. Many connecting and assembly operations are eliminated. There is no problem of lost conductivity. Cleaning time and expense are reduced because there are no deep crevices where tubing meets sheet.

Tubing contours smoothly into the sheet. Expansion, radius and bending problems inherent with tubing are eliminated. You can route refrigerants wherever they are needed. Passageways may be flat, oval or round. They can be smaller and can be placed closer together. Additional length adds nothing to the cost. Reynolds roll bonding is strong and compact. Passageways themselves act as stiffening ribs and contribute to the overall sturdiness of the unit.

For more details on Reynolds roll bonded aluminum sheet or for Reynolds engineering assistance on fabricated parts for your particular products, regardless of your industry, contact the Reynolds office listed under "Aluminum" in your classified telephone directory. Write for your free copy of the 20-page brochure, "Aluminum Appliance Parts" and the 24-page "Catalog of Facilities" to Reynolds Aluminum Fabricating Service, 2065 South Ninth Street, Louisville 1, Kentucky.

New Edition of "Aluminum Data" Offers Valuable Information to Aluminum Users

Reynolds Metals Company has just released the 1954 edition of the "Aluminum Data Book". It contains 220 pages of detailed information on the properties and characteristics of aluminum and is considered the most complete and up-to-date technical information on aluminum now available.



Text and tabular information on physical, chemical and mechanical properties of aluminum as well as data on tolerance, weight, fabricating characteristics, etc. have been expanded.

Entirely new information is presented on radioactive isotopes of aluminum, thermal neutron absorption cross sections for various metals, as well as the elements found in commercial aluminum alloys.

Other new material includes a section on "Availability" showing manufacturing limits on standard aluminum mill products and giving details on aluminum powders, pastes and chemicals. A section is devoted to the new alloy designation system just adopted by The Aluminum Association. New and old system equivalent tables are shown.

Single copies of the book are available to engineers, designers, technical men, instructors and executives without charge when request is made on a business letterhead. Address requests to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Reynolds Begins $2,585,000 Expansion of Sheffield, Alabama Sheet Mill

New melting equipment capable of producing about 90,000,000 pounds of aluminum annually is being installed as the first step in a broad expansion program planned for Reynolds sheet mill in Sheffield, Alabama. This will permit Reynolds to give better delivery to the ever-expanding market for aluminum sheet. Additional annealing facilities consisting of four new furnaces, each with a capacity for 120,000 pounds of aluminum coils are also being added to the plant.

A number of new buildings will be required to house the new melting and annealing facilities.

Fabricators Benefit from Reynolds Design Seal Program

More and more manufacturers are participating in the "Designed in Reynolds Aluminum" Seal program. Applied to the manufacturers' products it tells a stronger quality story at point-of-sale. Reynolds national magazine advertising and outstanding "Mister Peepers" TV show are benefiting Seal program participants.

For details on how your company can qualify for the Seal, write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Ky.

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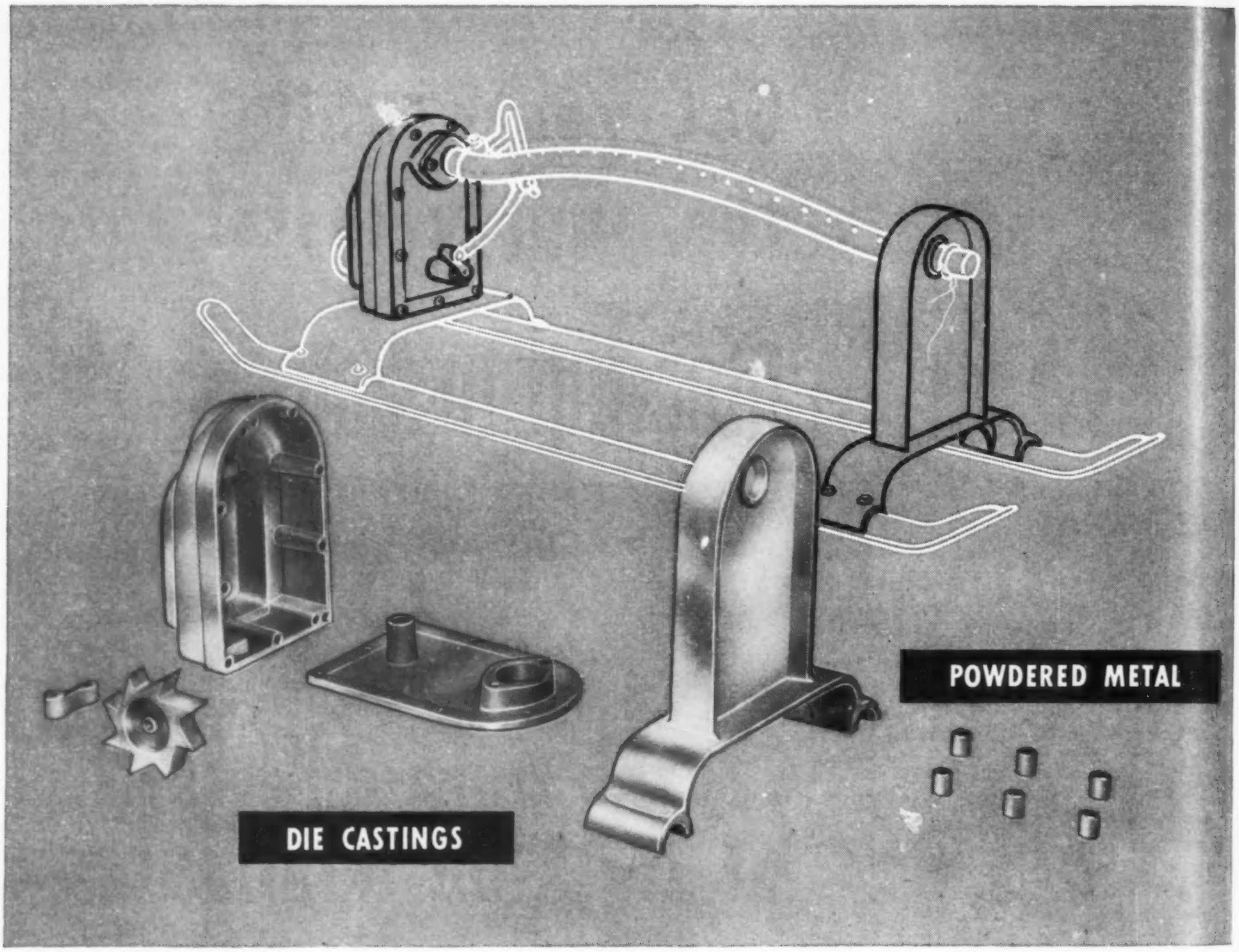

PARKER USES 2 MEANS TO 1 *Lower Cost* END

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Low cost—consistent with high quality—was the primary objective in producing important component parts for the popular lawn sprinkler made by Eastern Machine Products Inc. Parker gained this objective by making the end bracket, actuator housing, crank, and water wheel of aluminum die castings. The bushings inside the housing are bronze alloy sintered metal. The end result: component parts that meet every specification at lower cost.

This example emphasizes an important point about Parker service. No matter what your requirements in either die castings or powdered metal, Parker has the skill, experience and facilities to provide either or both. This undivided responsibility has saved money—and solved problems—for many users. Your problem may be one that Parker can solve in like manner. Just call the nearest Parker sales engineer listed at the left.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pa.

PARKER

ALUMINUM and ZINC
die castings

Select Schrader Blow Guns

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Drop-Forged Stainless Steel
practically indestructible—simple construction—parts easily replaced—protective hand guard and hang-up hook—comfortable grip—countersunk nose

Drop-Forged Brass Button Type
forged brass body—easy grip—parts easily replaced

Drop-Forged Brass Lever Type
forged brass body—easily controlled air blast—steel lever—comfortable grip—parts easily replaced

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A Schrader Blow Gun puts air where you want it . . . when you want it . . . and *just the way* you want it to do the job best. Choose from thirty-six designs and styles. Schrader Blow Guns take years of the toughest treatment you can give them—and come back for more. Here's why . . .

They're rugged both in design and construction. Bodies are drop-forged of either brass or stainless steel.

They're convenient—can be used anywhere. Blow gun circuits—using Schrader Couplers, Hose and Automatic Hose Reels—take little space, yet put compressed air right at your fingertips.

They're economical—they have few moving parts. And replacement parts, when and if needed, are easily installed.

They're versatile—with nine interchangeable noses—both fixed and adjustable—that fit all three standard-type guns, you can't think of a blow-gun application that Schrader can't meet.

It's easy to find out for yourself what a wide selection of blow guns is in the *complete Schrader Line* of air control equipment. Write today—or, if you prefer, fill out the coupon below.

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Write for your copy of SEALMASTER Catalog 454.

SEALMASTER'S
Patented
LOCKING PIN & PERIMETER DIMPLE

SEALMASTER

BALL BEARING UNITS

SEALMASTER BEARINGS

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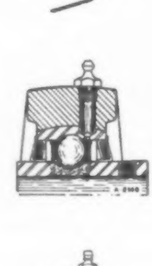
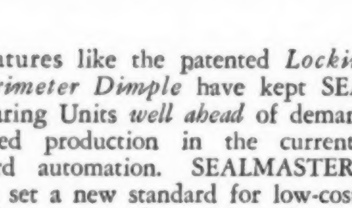
Features like the patented *Locking Pin* and *Perimeter Dimple* have kept SEALMASTER Bearing Units *well ahead* of demands for high speed production in the current trend toward automation. SEALMASTER leadership has set a new standard for low-cost in bearing maintenance and maximum bearing efficiency. It will pay you to consider the advantages of SEALMASTER Bearings in the machines you buy or build.

Rotation of outer race ring in the bearing housing is prevented . . . **eliminating housing wear.**

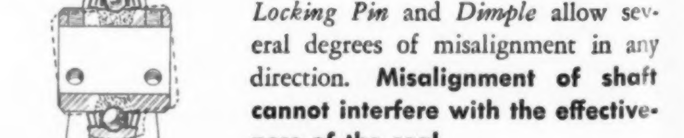
Locking Pin locates the lubricating hole within the *Dimple* on the outer race ring and has a V-shaped groove at each end to allow a free flow of grease from the grease fitting to the sealed bearing chamber . . . **assuring positive lubrication.**



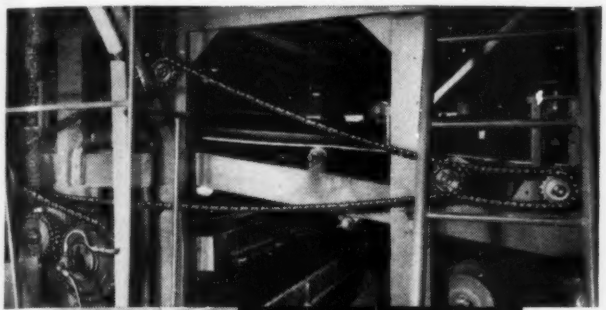
Locking Pin and *Dimple* allow several degrees of misalignment in any direction. **Misalignment of shaft cannot interfere with the effectiveness of the seal.**



FACTORY REPRESENTATIVES AND DEALERS IN ALL PRINCIPAL CITIES



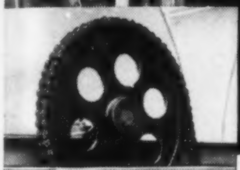
Are Your Drive Centers Long, Short or Medium?



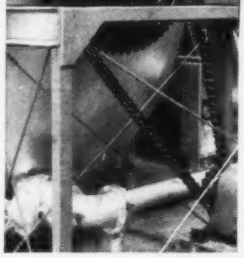
DIAMOND

ROLLER CHAINS

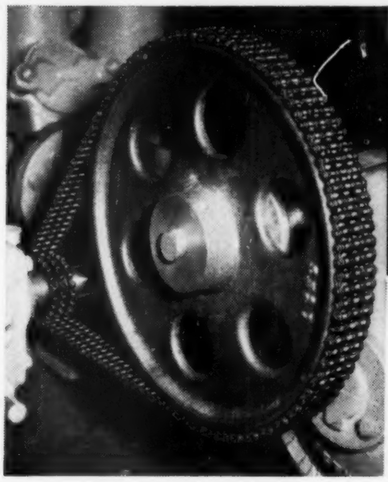
Provide Equally Positive Drives Regardless of Center Distances



LONG CENTERS LIKE THESE?



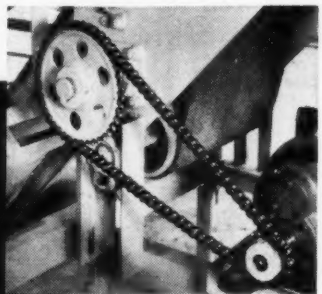
At Top: Long distance between centers and with idler sprocket, drive gets around obstructions.
At Left: Single No. 478 Diamond Roller Chain agitator drive on 5-foot center.

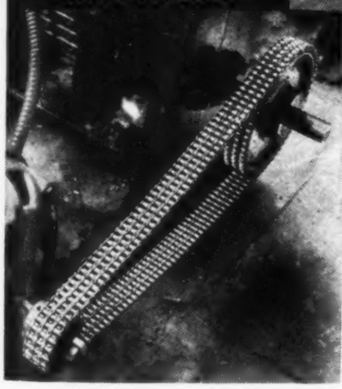


OR CENTERS SO SHORT SPROCKET TEETH BARELY CLEAR?

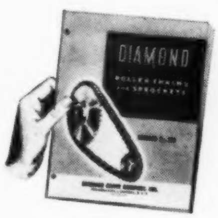
Short center high-speed motor drive — triple-strand Diamond Roller Chain.

OR MEDIUM CENTERED DISTANCES LIKE THESE?





Above: Drive to carton conveyor, 28-inch center distance.
At Left: Multiple-strand high speed motor drive.



Write for complete data Catalog 754.

■ Whether shafts are very close together or far apart—Diamond Roller Chain Drives transmit the power positively—without slip or drag.

Speeds selected or desired are accurately assured—productive output maintained at maximum, every hour of every day.

Diamond high-finish Roller Chains perform as smoothly as they look—every roller perfectly mated, cushioned in movement on films of oil. Little or no power is absorbed, with little maintenance throughout long years of useful life. Delays and replacements are avoided when you entrust your motor and machinery drives to Diamond Roller Chains.

Practical recommendations and a copy of new Catalog 754 are yours for the asking.

SHOT-PEENING SINCE 1944

Diamond Chain has long recognized that certain types of internal stressing of chain parts would increase fatigue resistance. To this end, link plates have been specially processed and chain rollers and other parts have been shot-peened since 1944.

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Sealing trailers at the seams

3M COMPANY

When you consider the amount of weathering to which a house trailer is exposed in the course of its service, you can appreciate the importance of effective, all-around sealing.

Finding a seal to keep out dust, weather and noise used to present a real problem. But it doesn't any longer—thanks to 3M's new ribbon-like sealer, EC-1202. Made of synthetic rubber, EC-1202 is extremely flexible and easy to handle. And it's reinforced with sturdy fabric so that it holds its dimensions and is exceptionally easy to apply.

On trailers, like the one pictured above, EC-1202 is used to seal metal corners and edges. Next, an extruded aluminum corner is bolted over it for extra protection, to provide a complete seal against weathering of all sorts.

See what adhesives can do for you... You can use EC-1202 wherever metal corners, edges, or faying surfaces need sealing. Your 3M sales engineer will give you all the facts on this and other 3M adhesives developed for industry. Call him, or write today for free informative booklet—to 3M, Dept. 1912, 417 Piquette Ave., Detroit 2, Mich.

see our catalog in PRODUCT DESIGN FILE or write for copy

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For All Engines . . . this new, low cost, easily assembled hose line for fuel, oil, water, air

AEROQUIP

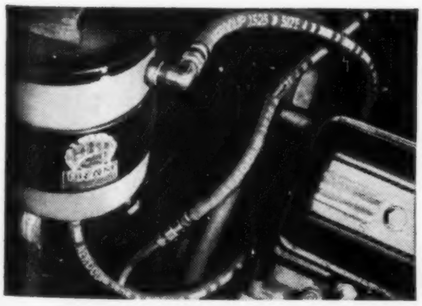
SOCKETLESS

FITTINGS AND HOSE

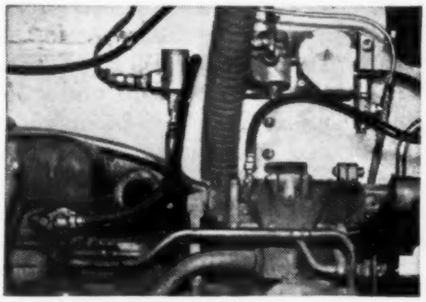
Eliminate the high cost of forming and fitting rigid tubing. Flexible hose lines made with Aeroquip Socketless fittings and hose install quickly, even in confined areas. They withstand heat, cold, shock and vibration encountered in all types of engine operation.

Aeroquip's low cost 1525 hose and Socketless fittings assemble *in seconds.* Just cut the hose to length and push the fittings into the hose . . . the fittings *stay on.* Available in ¼, ⅜, ½, and ⅝" sizes. Write for full information.

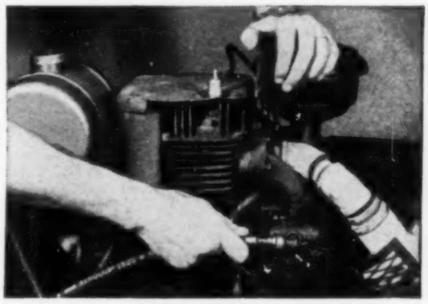
HERE ARE ONLY A FEW TYPICAL ENGINE APPLICATIONS



Aeroquip Socketless fittings and hose were used to make oil filter and fuel lines on this automobile engine.



Socketless fittings and hose were used to make the air unloader line to the O-1 governor on this G.M. coach.



This power mower fuel line points up the ability of Socketless fittings and hose to withstand vibration.

Aeroquip

REG. TRADE MARK

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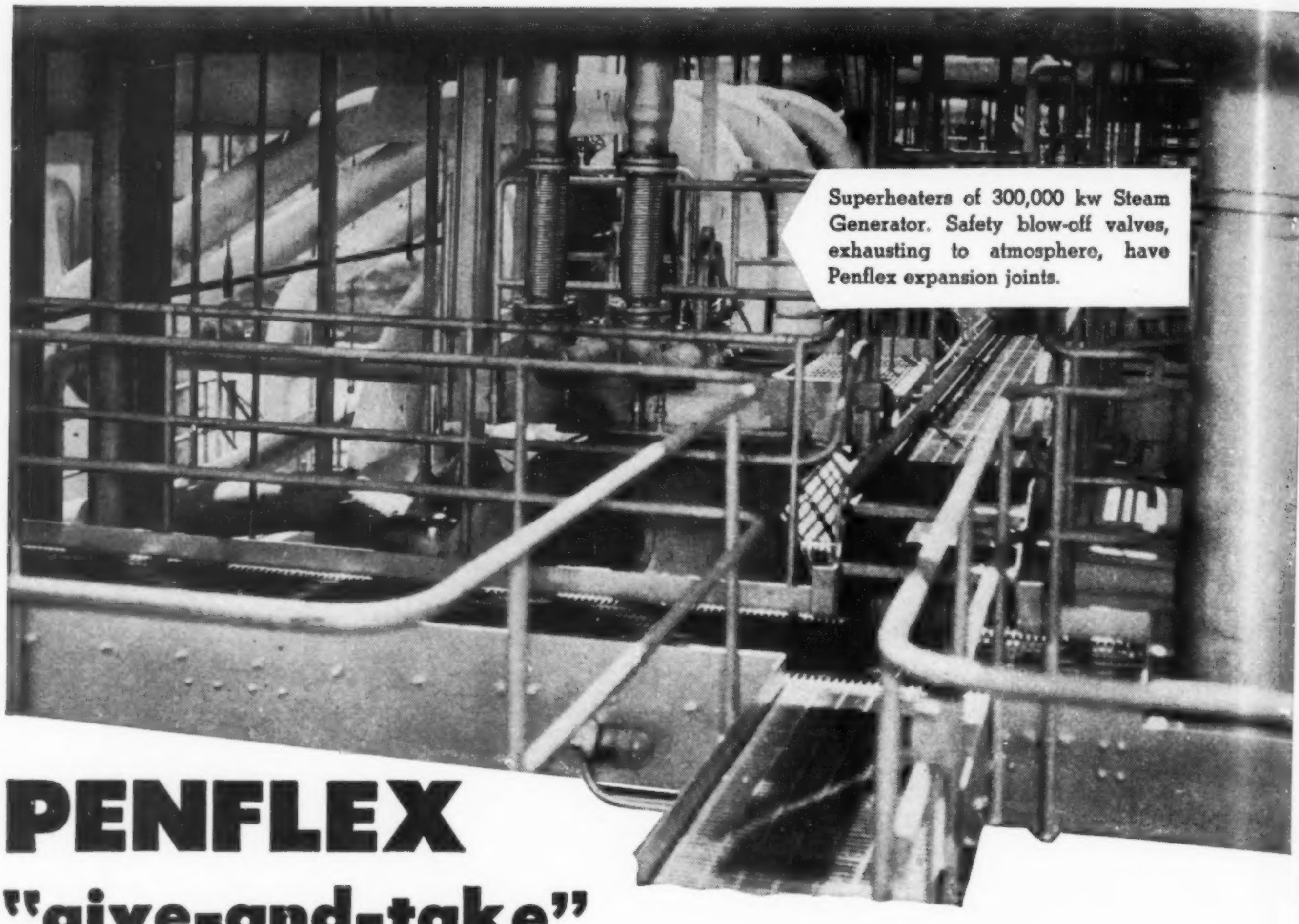
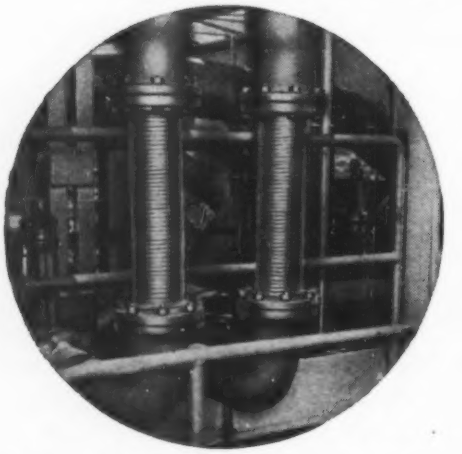


PENFLEX

"give-and-take" prevents blow-outs on blow-offs



Penflex Galvanized Steel Interlocked Tubing (8" I.D.), flanged at both ends. Installed as expansion joints on safety blow-off valves, they take up to 850 psi steam pressure at 900°F.

Power plant applications like this one can't use less than Penflex Metal Tubing offers in flexibility, strength, and tightness. When safety valves go, expansion joints must hold. Penflex joints *do*. That's because they can give with the pressure and take it, too.

Thermal expansion at 900°F. . . . pressures up to 850 psi . . . impact and pipe movement under these strains—all are safely handled by Penflex. Forty-two complete units in this big power plant are protected from blow-outs by Penflex.

There are hundreds of other applications in the steam and diesel power fields for Penflex Interlocked Tubing and Penflexweld High-pressure Tubing. Call in the Penflex engineer to help you on your own particular problems. In the meantime, write for "Flexineering," your guide in buying and using Penflex Flexible Metal Tubing. There is no charge or obligation.

Pennsylvania Flexible Metallic Tubing Company, Inc., 7239 Powers Lane, Phila. 42, Pa.
Branch Sales Offices: **Boston • New York • Chicago • Houston • Cleveland • Los Angeles and Distributors in Principal Cities**

COMBINES FLEXIBILITY WITH DURABILITY

want high speed plus endurance? How's this . . .

1000 HOURS at 3600 R.P.M. UNDER FULL LOAD!

If you were to drive 90,000 miles up an incline at 90 m.p.h., you would approximate the performance of the Model 24A, 331 cubic inch displacement Chrysler Industrial Engine pictured below.

To prove the power of Chrysler Industrial V8 Engines . . . their ability to run for long periods of time at high speed . . . on March 17, 1954 Chrysler engineers placed a production model Ind. 24A Engine on an endurance dynamometer at Chrysler Central Engineering Laboratories. Objective: 1000 hours operation at 3600 R.P.M. under full load.

During every one of the 1000 hours, the Chrysler Ind. 24A Engine delivered an average of 174 horsepower and when shut down, the engine was still in perfect operating condition.

During the run no service was necessary beyond minor maintenance care, such as oil changes and very infrequent spark plug changes and point adjustment. Yet, following disassembly of the engine, the only wear noted was negligible—no more than you might expect from an engine that has been operated for 1000 hours within a long period of time.

While there is every reason to believe that this is a record-breaking endurance run (and don't forget it was made at 3600 R.P.M. under full load), we are confident that every Chrysler Industrial V8 Engine will *at least equal* this astounding record.

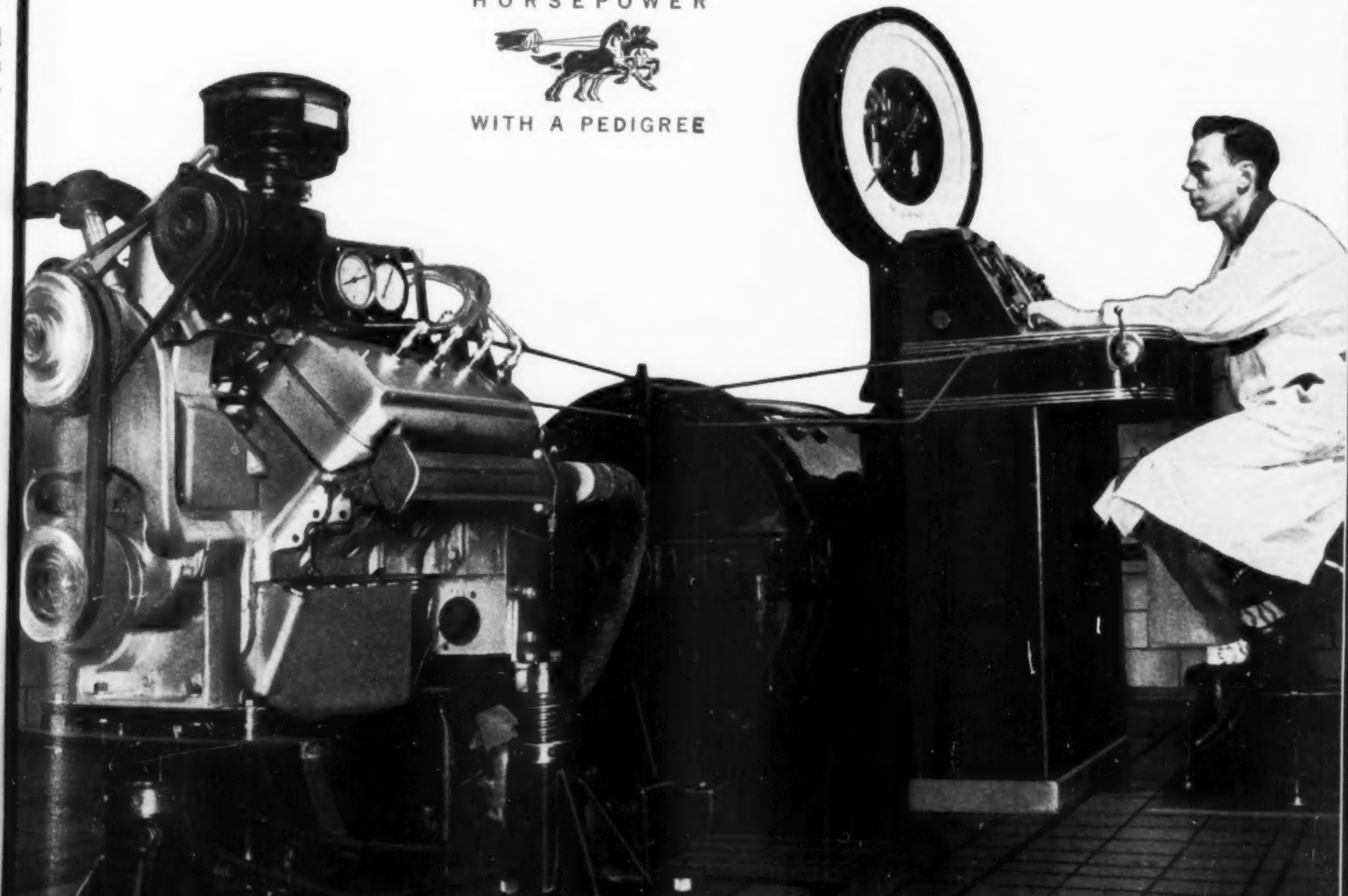
This proves too, beyond a doubt, that the Chrysler Industrial V8 hemispherical combustion chamber design with its short-stroke, low-friction construction, makes an ideal power plant for any equipment that requires continuous high speed operation. Furthermore, in installing a Chrysler V8 Engine in preference to a diesel engine of similar horsepower, you can reduce your size estimate by one-half, your weight by two-thirds, and your cost factor by three-quarters!

For detailed information on the Model 24A or any Chrysler Industrial Engine, see a Chrysler Industrial Engine Dealer, or write: **Dept. 612, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.**

CHRYSLER *Industrial Engines*

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

HORSEPOWER WITH A PEDIGREE



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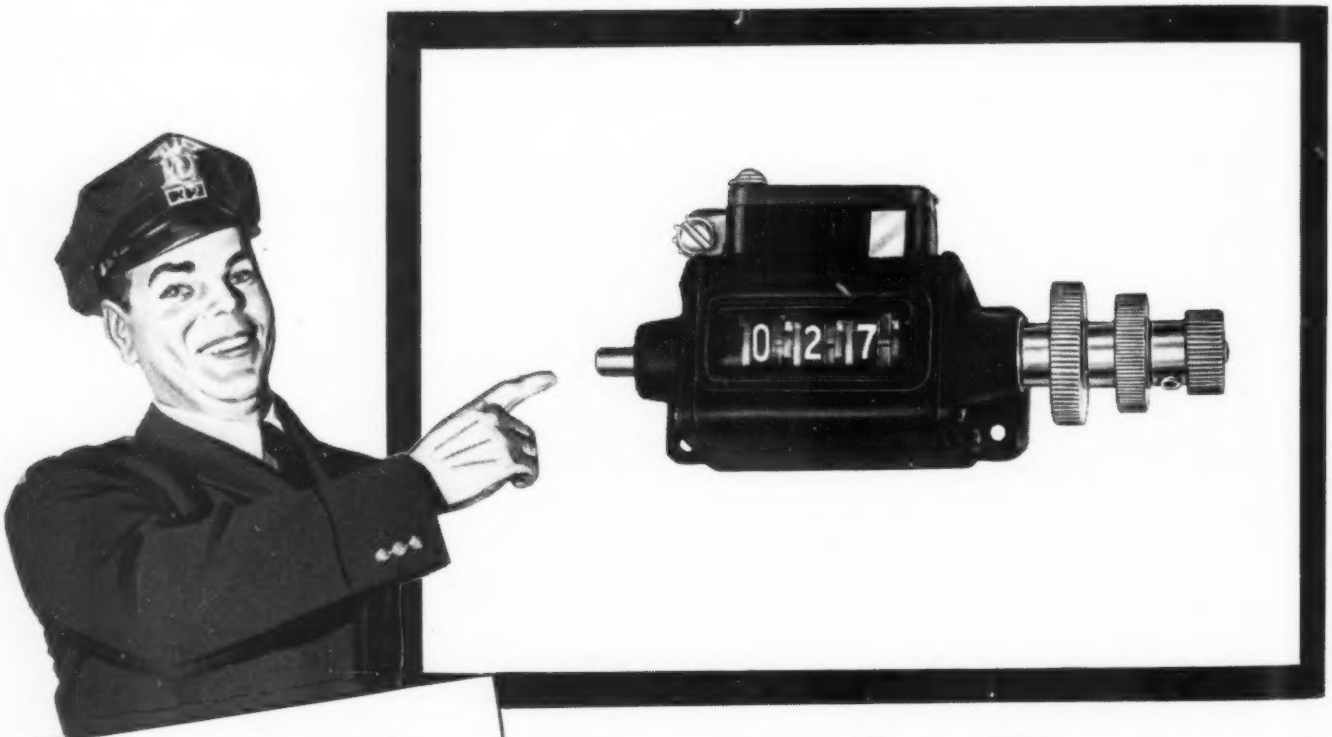
Here's a New

"TRAFFIC COP"

for short high-speed runs



Added Evidence that—

Everyone Can Count on

VEEDER-ROOT

This new small Predetermining Ratchet Counter is set for any run up to 1,000 counts, pieces or other units by the three knurled setting knobs. Then it subtracts to zero, and at that point actuates a contact to light a light, ring a bell or stop the machine. Compact and easy to reset, this counter makes an attractive new selling feature when built into a machine as a standard integral part. And it's just one of scores of standard and special Veeder-Root Counters for every mechanical and electrical application in any field from atomics to automation. What would *you* like to count? Let Veeder-Root figure out how to do it. Write:

VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT

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Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
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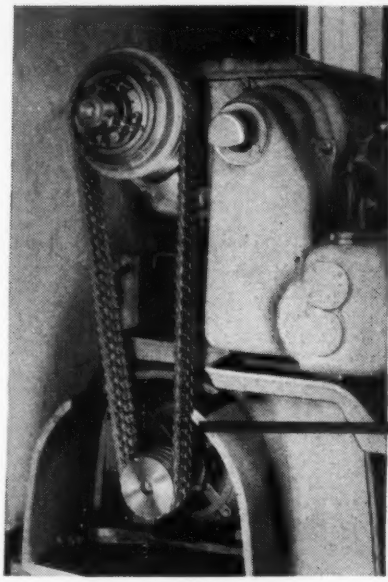
® **"The Name that Counts"**



Performance Proves

20% to 90%

LESS VIBRATION

with Veelos—the Balanced V-belt

Engineers have long known that there are four principal causes of machine vibration: 1. bearings; 2. motor; 3. clutch; 4. sheaves. Often overlooked is a fifth cause: v-belts. And, in many instances, *v-belts alone* are the major cause of vibration.

There's a logical reason for this.

Regular v-belts have spots of varying density due to their construction. Normally, these spots are not apparent, yet they throw the belt out of balance when the drive is operating. As a result, vibration is created that can damage bearings, shafts and, most important, the finished work.

This is not true of Veelos v-belts.

Veelos is absolutely uniform throughout its entire length. Every link and every stud is identical. The smooth, machine-cut sides and the laminated construction assure smooth, vibrationless power delivery. Veelos is perfectly balanced.

In case after case, installation of Veelos v-belts has reduced machine vibration 20% to 90%.

Proof that Veelos will reduce vibration can easily be demonstrated with an electronic vibration analyser. This analyser measures amplitude of vibration to as low as 2-millionths of an inch.

Fifteen minutes of your time is all that is required to show you with the electronic analyser that Veelos creates less machine vibration. Drop us a line or clip the coupon for a demonstration.

Manheim Manufacturing & Belting Company
606 Manbel St., Manheim, Pa.

***Yes, I would like a demonstration.* Have your representative call me for a convenient time.**

Name..

Company...

Address...

....

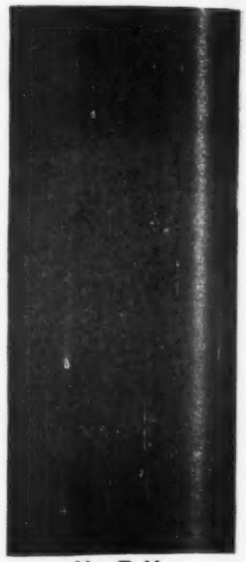
VEELOS
THE LINK
V-BELT

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

Veelos is known as Veelink outside the United States.

2CV

Type 316



No. 7-Mo

How Can Corrosion Control Service Like This

Pay Off For You ?

No doubt about it . . . your corrosion problems are different. In working with plant after plant we know this is true. We also know that one of the phenomena of corrosion resisting steels is that there doesn't seem to be a cure-all. This is exactly why we have equipped ourselves, through constant laboratory research and field work, to render a truly helpful corrosion control service for plants like yours. This service includes development of totally new steels such as Carpenter No. 20, a super corrosion resisting stainless that comes closest to providing the answer to economical handling of a wide range of chemicals, including hot sulphuric acid.

What's *your* corrosion problem? Perhaps Carpenter's Corrosion Control Service, backed by experienced metallurgists, can help solve it. Take time now to drop us a line on your company letterhead. At no obligation, we'll be glad to work with you. THE CARPENTER STEEL COMPANY, 120 W. Bern St., Reading, Pa.

SOLVED:

A Tough Problem in Handling NITRIC-HYDROFLUORIC ACID

Problem:

An eastern plant was using Stainless Type 316 for baskets, racks, etc., in a pickling process involving a solution of nitric-hydrofluoric acid. The concern was running up against costly problems caused by fast deterioration of the equipment. Then they threw the problem in Carpenter's lap. We worked closely with them right from the start . . . supplied test samples of several Carpenter Stainless grades.

These were inserted in the solution (17% nitric acid, 6½% hydrofluoric acid) under actual operating conditions. Part of each specimen was held in the quiescent portion of the solution . . . and part of each was exposed to the aerated condition. They were exposed continuously, to the same medium encountered in normal operation, for a period of 117 days.

Statistics:

Agitation: None *Temperature:* 70 to 130°F
Contaminants in Bath: chromium, iron, nickel salts, along with a sludge of metallic oxides

Of the samples tested, Carpenter No. 7-Mo provided the best results. For example, here are results in loss of metal comparing Stainless Type 316 with No. 7-Mo:

Loss of metal, in inches per month:

No. 7-Mo	.0009 ipm
Type 316	.0074 ipm

These results indicated to the concern that baskets and racks made from Carpenter No. 7-Mo will last *eight times longer* than those made from Type 316.

Carpenter STEEL

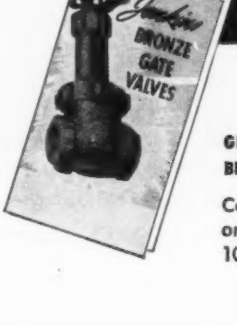
Super Corrosion-Resistant Stainless

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research

Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

40 reasons why any service requiring **BRONZE GATES** can be planned for lasting economy

Look over the list of 40 patterns in Jenkins' complete line of Bronze Gates. You'll find the valve you need in this new folder, with details of the *extra value* design and construction that makes Jenkins the best buy for any service. Get this folder, use it to plan your hookups for lasting valve economy.



GET THIS NEW BRONZE GATE FOLDER

Call your Jenkins Valve Distributor or write: Jenkins Bros., 100 Park Ave., New York 17.

JENKINS

LOOK FOR THE JENKINS DIAMOND

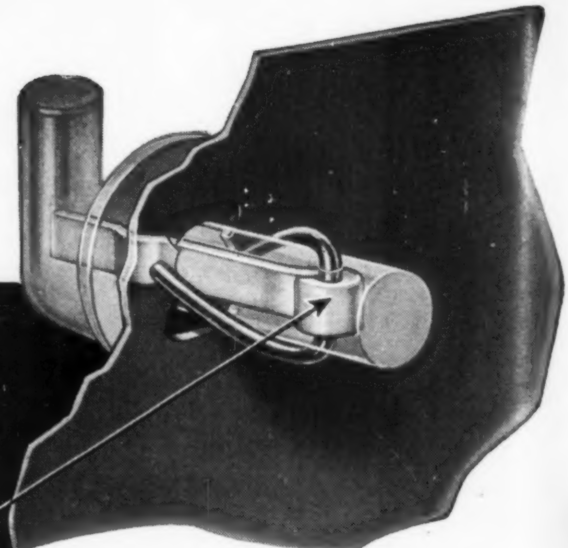
VALVES

SINCE 1864 JENKINS

Jenkins Bros

SOLD THROUGH LEADING DISTRIBUTORS

The ONLY plastic shelf support with the heart of steel



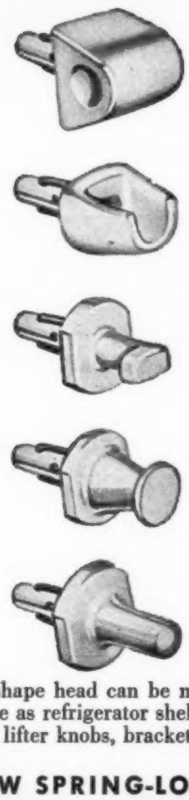
This steel insert, molded into plastic Spring-Locks, gives strength where it's needed—at the point of load or impact—eliminates doubts concerning the strength of plastic at these critical points. The metal insert increases the load-carrying capacity of the entire assembly.

The design flexibility of plastic Spring-Locks makes them ideal for a variety of applications. Shelf supports, washer cover knobs, drawer pulls and many other products made by such companies as Frigidaire, Philco, Easy Washing Machine and International Harvester have utilized the combination of utility, beauty and strength these versatile fasteners provide.

Spring-Locks cut material and assembly costs, too. No special tools, bolts, nuts or threadings required. Just a half-turn locks them securely, another quarter-turn and they're free.

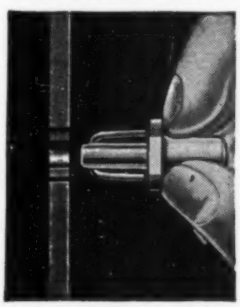
Many standard shapes and sizes of Simmons Spring-Locks are available from stock—or any shape head can be designed for your individual needs. Whatever your fastening problem, we'll be glad to help you solve it. Why not send us the details, or call in a Simmons engineer today?

SIMMONS FASTENER CORPORATION
1756 NORTH BROADWAY, ALBANY 1, N. Y.

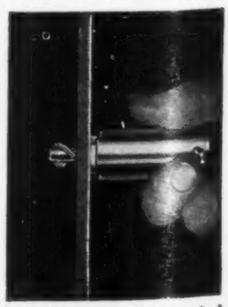


Any shape head can be molded for use as refrigerator shelf supports, lifter knobs, brackets, etc.

HERE'S HOW SPRING-LOCKS WORK



1. Insert Spring-Lock



2. A half-turn and it's locked

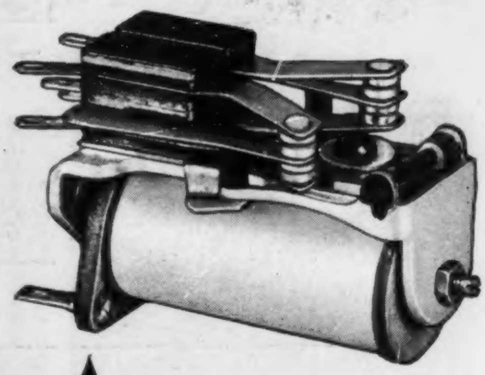
The steel insert carries the load.

Simmons

QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

JUST OUT!
NEW 36-PAGE CATALOG WITH APPLICATIONS
SEND FOR IT!

New variety of CLARE Type J Relay provides a power relay as sensitive and accurate as telephone-type relay



1 Handles inrush current of 50 amperes for 50,000 operations—rating of 10 amperes, $27\frac{1}{2}$ volts d-c.

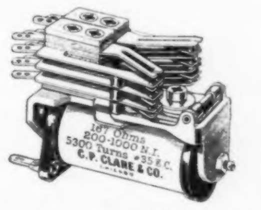
2 Has exceeded 500,000 operations on motor load of 6 amperes—inrush current of 15 amperes—at 70,000 feet altitude.

The new CLARE Type J Relay has all the advantages of the small size, light weight and sturdy construction which makes the standard Type J Relay so popular with designers of electrical and electronic equipment.

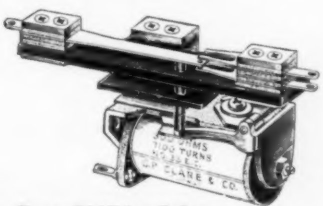
Increased current carrying capacity is provided by the use of Code 18 (Silver) heavy duty contacts which are riveted to the springs. A combination of the standard Type J twin contacts and the new heavy duty contacts is also available.

Nominal rating of this new Type J Relay is: 10 amperes, 115 volts a-c (resistive); 10 amperes, $27\frac{1}{2}$ volts d-c. The relay is $2\frac{1}{4}''$ long, $1\frac{1}{8}''$ wide and $1\frac{3}{8}''$ high with two Form C contacts.

Long life and increased adjustment stability is provided by a new hinge-type armature. The new heavy-duty yoke has a stainless steel pivot pin with a large bearing surface which turns in precisely reamed bearings of nonferrous material.



Standard Type J Relay with independent twin contacts



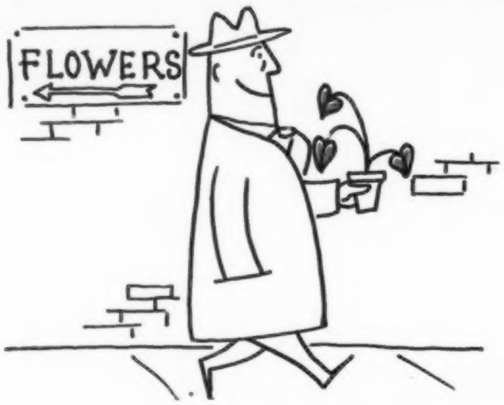
Type JV Video Relay for high frequency currents

For complete information write for CLARE *Bulletin No. 119. For information on other variations of the Type J Relay send for our Engineering Data Book. Address: C. P. Clare & Co., 3101 West Pratt Blvd., Chicago 45, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address:* CLARELAY.

CLARE RELAYS

FIRST in the industrial field

... things to watch for when buying Philodendron



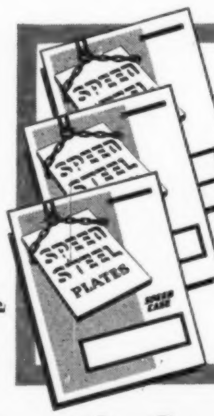
But if you're buying special purpose STEELS, may we recommend the SPEED STEELS

SPEED CASE	a low carbon free machining open hearth steel
SPEED TREAT	a medium carbon free machining open hearth steel
SPEED ALLOY	a chromium alloy steel

briefly they ✓ are easy to heat-treat ✓ are fast machining ✓ give longer tool life ✓ produce better finishes

THERE ARE SPEED STEEL SPECIALISTS IN...

☐ Akron, Ohio	Burger Iron Co.
☐ Bridgeport, Conn.	Bridgeport Steel Co.
☐ Buffalo, N. Y.	Beals, McCarthy & Rogers
☐ Cambridge (Boston), Mass.	Brown Wales Co.
☐ Chicago, Ill.	W. J. Holliday & Co., Inc.
☐ Dallas, Tex.	Earle M. Jorgensen Co.
☐ Detroit, Mich.	Peninsular Steel Co.
☐ Hammond, Ind.	W. J. Holliday & Co., Inc.
☐ Houston, Tex.	Earle M. Jorgensen Co.
☐ Indianapolis, Ind.	W. J. Holliday & Co., Inc.
☐ Lewistown, Me.	Brown Wales Co.
☐ Los Angeles, Calif.	Earle M. Jorgensen Co.
☐ Memphis, Tenn.	Pidgeon-Thomas Iron Co.
☐ Newark (New York), N.J.	Grammer, Dempsey & Hudson, Inc.
☐ Oakland (San Francisco), Calif.	Earle M. Jorgensen Co.
☐ Philadelphia, Pa.	Horace T. Potts Co.
☐ Toronto, Ontario	Peckover's, Ltd.
☐ Tulsa, Okla.	Earle M. Jorgensen Co.



Write Today!

for new SPEED STEEL bulletins: 541 • 542 • 543

☐ *Bulletin 541* • SPEED CASE

☐ *Bulletin 542* • SPEED TREAT

☐ *Bulletin 543* • SPEED ALLOY

W. J. Holliday & Co., Inc.

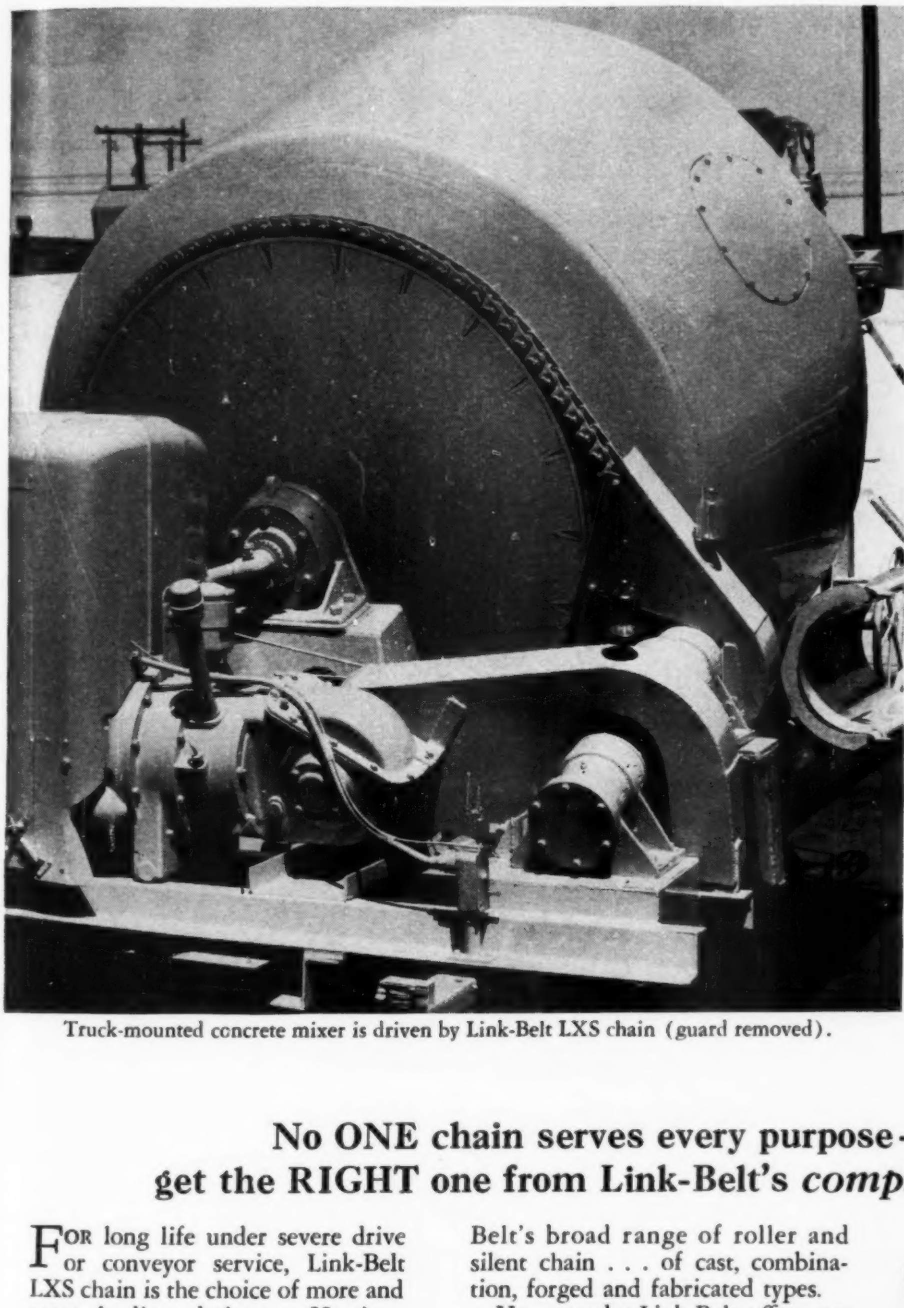
141 141st STREET • HAMMOND, INDIANA

Speed steels are produced by W. J. Holliday & Co., Inc., Speed Steel Plate Division

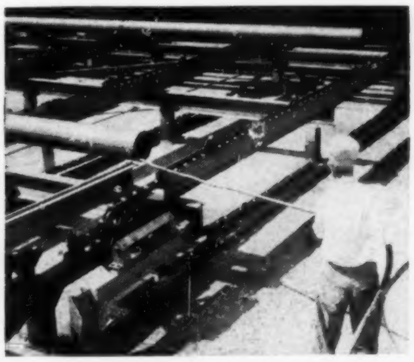
Leading design engineers choose this

Chain for severe conditions

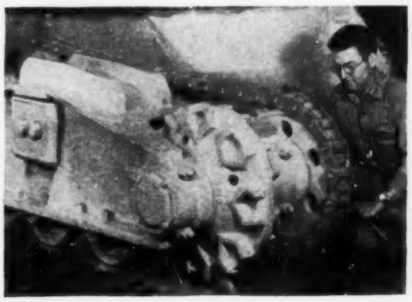
...it's LINK-BELT LXS for drives and conveyors



Truck-mounted concrete mixer is driven by Link-Belt LXS chain (guard removed).



Pipe mill cooling beds use LXS chain with attachments to move heavy pipe smoothly.



Advance-design shovel-crane gets its traveling and steering power through LXS chain.

Accurate sizing of full-round pins, bushings and pitch holes of LXS chain assures proper joint clearances and press fits.

No ONE chain serves every purpose--
get the RIGHT one from Link-Belt's *complete* line

FOR long life under severe drive or conveyor service, Link-Belt LXS chain is the choice of more and more leading designers. Here's a fabricated steel roller chain that *combines ruggedness with accuracy,* thanks to the manufacturing refinements that are a by-word at Link-Belt.

It's the same story for every drive and conveyor requirement — you'll find the chain that's *best* for the job in the complete Link-Belt line. No other single source can equal Link-Belt's broad range of roller and silent chain . . . of cast, combination, forged and fabricated types.

Your nearby Link-Belt office can give you all the facts. Why not call today for an expert, unbiased appraisal of your needs?

LINK-BELT

13,604

CHAINS & SPROCKETS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

Here's help in

ORDERING HYDRAULIC VALVES!

Use the form below to get specific information, prices, circuit designs and other data you may need on hydraulic valves.

Rivett catalogs 190 standard models in all popular sizes, types, actions, piston designs and pressures. Nearly any hydraulic valve requirement you may possibly have can be filled by Rivett. And Rivett's Factory Engineers and experienced Sales Representatives will assist in planning the most efficient circuits for your operations.

We are interested in the Hydraulic Valves checked below.
☐ Send complete literature and specifications. ☐ Send quotations on items checked. ☐ Have our Rivett Representative call and supply circuit information. ☐ Our specific hydraulic problem is: ______________

____

____

Mail This Form Today. Or File For Future Use!

RIVETT LATHE & GRINDER, Inc.,
Fluid Power Division
Dept. MD 12 Brighton 35, Boston, Mass.

☐ Hand
Operation:
- ☐ Threaded Stem
- ☐ Lever
- ☐ Knob

Action:
- ☐ Manual
- ☐ Spring
- ☐ Ball Detent

☐ Cam
☐ Foot
☐ Direct Solenoid Operated
Mounting:
- ☐ Pipe
- ☐ Sub-Plate
- ☐ Double Solenoid No Spring
- ☐ Single Solenoid Spring Return
- ☐ Double Solenoid Spring Centered

☐ Solenoid Pilot Operated
Mounting:
- ☐ Pipe
- ☐ Sub-Plate
- ☐ Double Solenoid No Spring
- ☐ Single Solenoid Spring Return
- ☐ Double Solenoid Spring Centered

☐ Oil Pressure Operated
- ☐ No Spring
- ☐ Spring Return
- ☐ Ball Detent
- ☐ Spring Centered

☐ Air Pressure Operated
- ☐ No Spring
- ☐ Spring Return
- ☐ Spring Centered

☐ Oil Pilot
Mounting:
- ☐ Pipe Line
- ☐ Base
- ☐ Foot
- ☐ Panel

☐ Flow Control
☐ Check
Mounting:
- ☐ Pipe
- ☐ Flange
- ☐ Spring Loaded
- ☐ Pilot Operated
- ☐ Pilot Operated with Pressure Breaker

☐ Shut Off

☐ Deceleration
☐ Relief
☐ Unloading
☐ Sequence
- ☐ Direct Operated
- ☐ Remote Operated
- ☐ With Integral Check

☐ Counter-Balance

Sizes
☐ ¼, ☐ ⅜, ☐ ½, ☐ ¾, ☐ 1, ☐ 1¼, ☐ 1½

Pressures
☐ 1500 P.S.I. ☐ 3000 P.S.I.

Specify Valve Action Desired

____

____

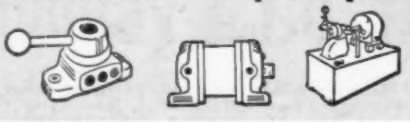
____

NAME______________ TITLE______________

COMPANY______________ CITY______________ STATE______________

RIVETT

furnishes a complete power package



VALVES • CYLINDERS • POWER UNITS
Air and Hydraulic
All sizes and types

Now—by American Pulley—a *complete* line of steel conveyor pulleys with split tapered, clamp-type hubs at *no extra cost*

Send for this

This new catalog on the complete American Conveyor Pulley line is yours for the asking. Write for it today.

For the first time, you can buy conveyor pulleys with split tapered hubs in *all sizes* down to 6″ diameter x 12″ face! Moreover, this new line, Type "HD", is designed and built to take the extreme loads of today's wider, larger-capacity, more rugged belt conveyors.

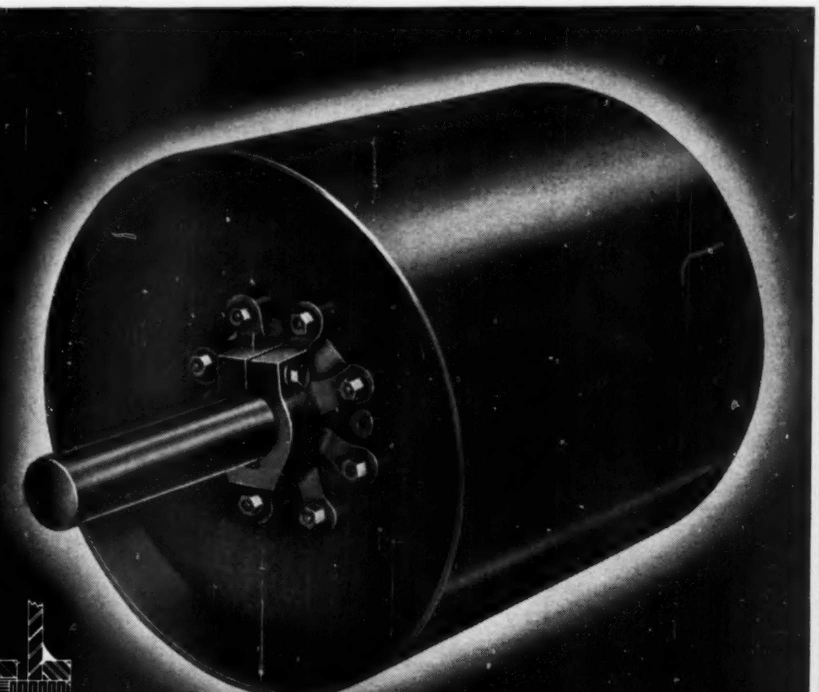
Heart of the "HD" pulley is the "WT" (Wedg-Tite) hub. This massive, split tapered hub squeezes its shaft with a bulldog clamp-grip to prevent hub wear, bell-mouthing and pulleys from "walking" on their shafts—makes pulleys easier to install or remove from shafts. Keys now become necessary only on drive pulleys.

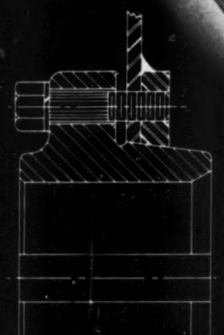
American Type "HD" Conveyor Pulleys with split tapered hubs are available as standard—crown or straight face—in sizes from 6″ through 60″ diameter, 12″ through 66″ face, and for shaft sizes through 10″ diameter. Larger sizes are built to specification.

For applications where lagged pulleys are required, be sure to investigate American Pulley's exclusive Griplex Spiralagging. This unique, inexpensive, top-quality covering can easily be repaired or replaced.

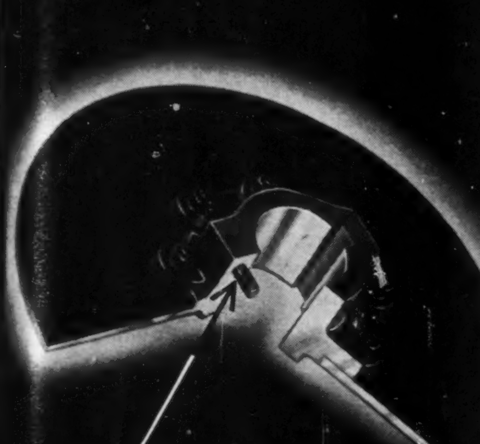
Two other pulleys, Type "L"—for light duty applications—and Type "O"—where split construction is required—are also available. See your local distributor or write today for full information. The American Pulley Company, 4236 Wissahickon Avenue, Philadelphia 29, Pa.

American Pulley's split tapered Wedg-Tite hubs are drawn into place by six or eight full-threaded, high-tensile bolts. Tapered hub shoulder *locks* onto machine-tapered disc—takes belt tension and driving load off bolts to eliminate disc, bolt, and hub wear.





Pulleys with bores over 4 7/16″ have a heavy steel backing ring tack-welded to inner side of each end disc and taper-bored with it. When hub is drawn into recess formed in disc and backing ring, it squeezes the shaft in a grip of maximum power.



Smaller sizes of Wedg-Tite hubs have an extra cross-clamp bolt threaded into a tapped hole for dual gripping action. When all bolts are tightened, hub is tightly clamped to shaft for its entire length—prevents pulleys "walking" on shafts.

At the Profit End of the Machine

Power Transmission by
AMERICAN
PULLEY COMPANY

(Advertisement)

Advantages of Worm Gearing

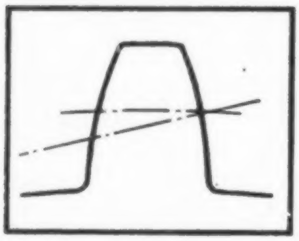
By J. E. Gutzwiller

Assistant Chief Engineer, Worm Gearing Department

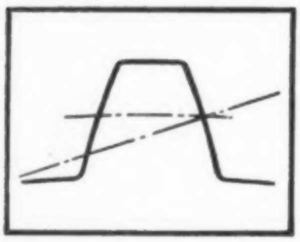
De Laval Steam Turbine Company

Interchangeability—The De Laval Steam Turbine Company was one of the first, if not the very first, manufacturer of heavy duty machinery to build worm gearing with interchangeable parts manufactured under limit gage control. Thus, worm and gear sets of like center distances but of different ratios can be readily interchanged if revision of speeds becomes necessary. Standard parts are always available for maintenance.

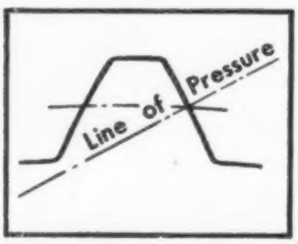
High Shock Load Capacity—The worm gear tooth form is such that the gear teeth are under a crushing, rather than a bending load. For this reason extremely high momentary and shock loads, damaging to many forms of gearing, can be successfully withstood. High momentary overloads seldom cause failure, as worm gear ratings are figured on the wear resistance of the gear teeth.



Standard 14½° involute spur gear tooth and old time worm tooth.



20° stub gear tooth.



De Laval Worm Gear Tooth. Note, line of pressure falls inside base of tooth.

Long Life—Bronze gear teeth maintain their correct form due to the regenerating action of the hardened steel worm, which retains its original shape throughout years of wear. A worm gear drive actually improves with service. This fact is peculiar to worm gearing and contributes to its recognized long life.

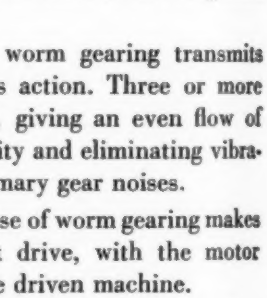
Smooth, Quiet Power—De Laval worm gearing transmits power by a continuous shockless action. Three or more teeth are in contact at all times, giving an even flow of torque and uniform angular velocity and eliminating vibration, pulsation, chatter and customary gear noises.

Compact Right Angle Drive—The use of worm gearing makes a neat, closely coupled, compact drive, with the motor shaft at right angles to that of the driven machine.

Larger Gear Ratios Simplify Design—Worm gearing offers larger ratios of speed reduction in a single compact set, another space-saving feature for the design engineer. The larger gear ratios obtainable in a single worm and gear set reduce the number of moving parts required.

Safety and Ease of Maintenance—The small number of moving parts in a worm gear drive may be readily enclosed, thus avoiding the hazard of exposed moving parts. Assuming proper lubrication, worm gearing operates with minimum attention, even under the most adverse conditions.

Reference Manual On Worm Gear Sets



Design engineers will find this new catalog a helpful working tool in the selection of worm gear sets. It contains examples of how to select worm gearings, worm and gear data, standard worm mounting dimensions, horsepower ratings, data on shaft stresses as well as other information.

Write on your business letterhead for Catalog 5000 to De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, New Jersey.

DL 285

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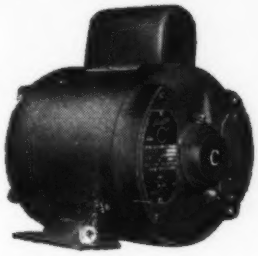

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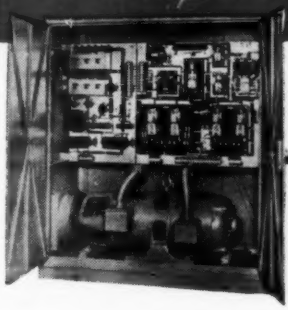

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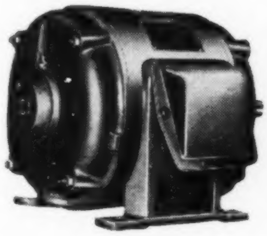

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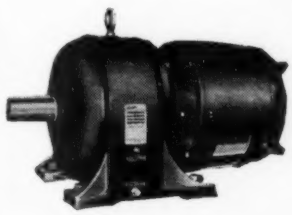

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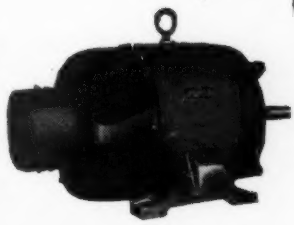

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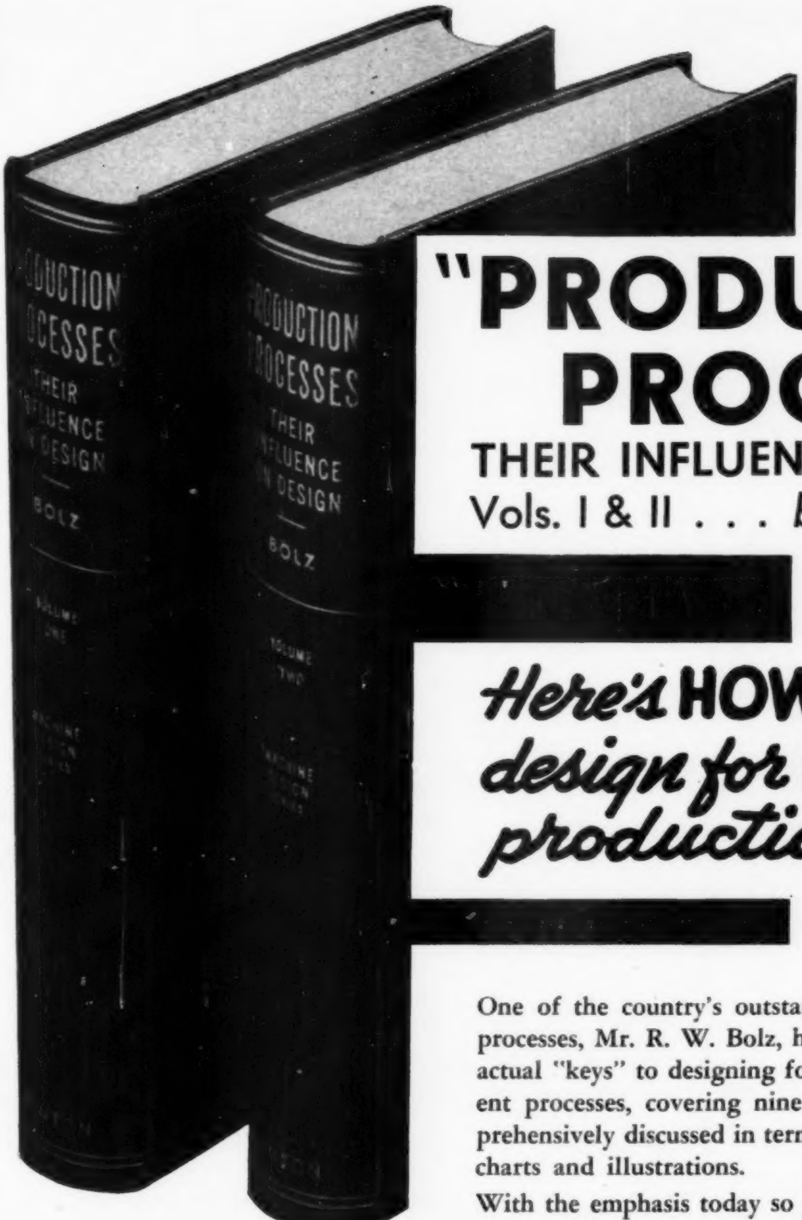

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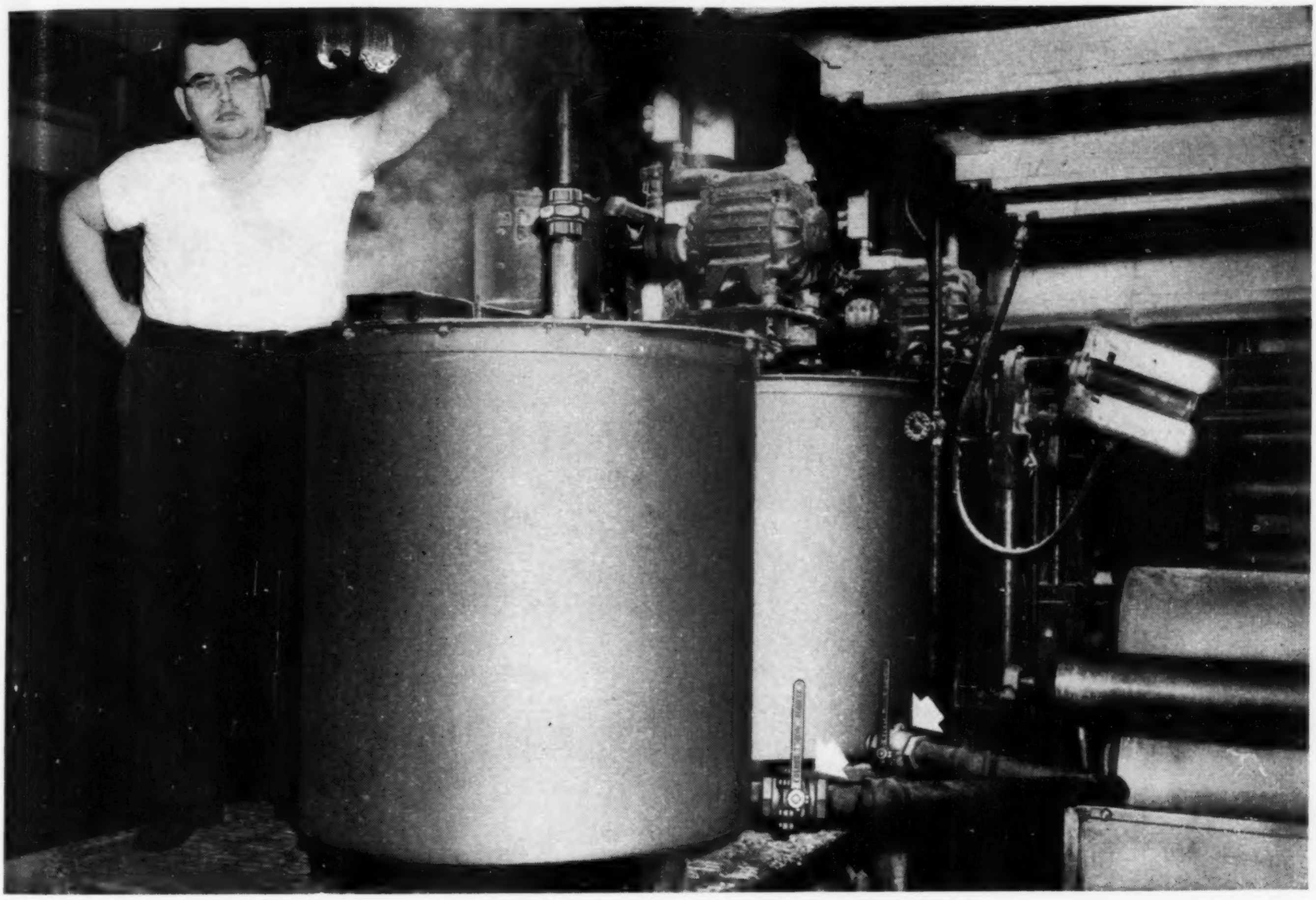

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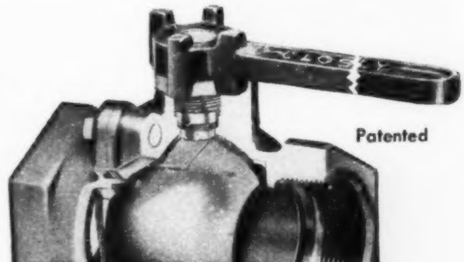

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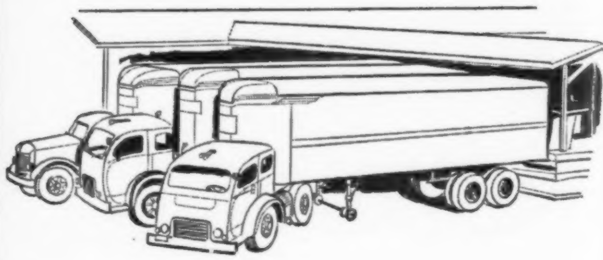

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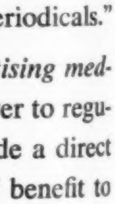

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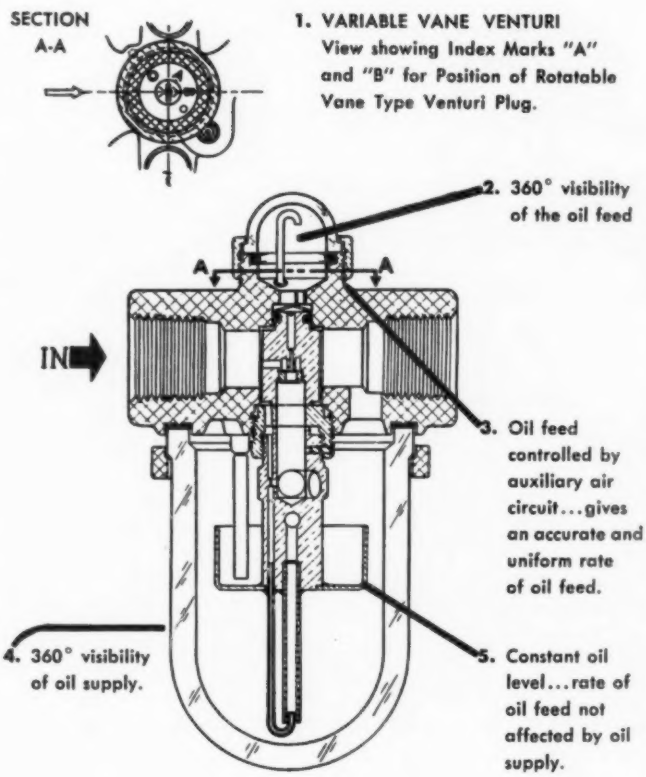

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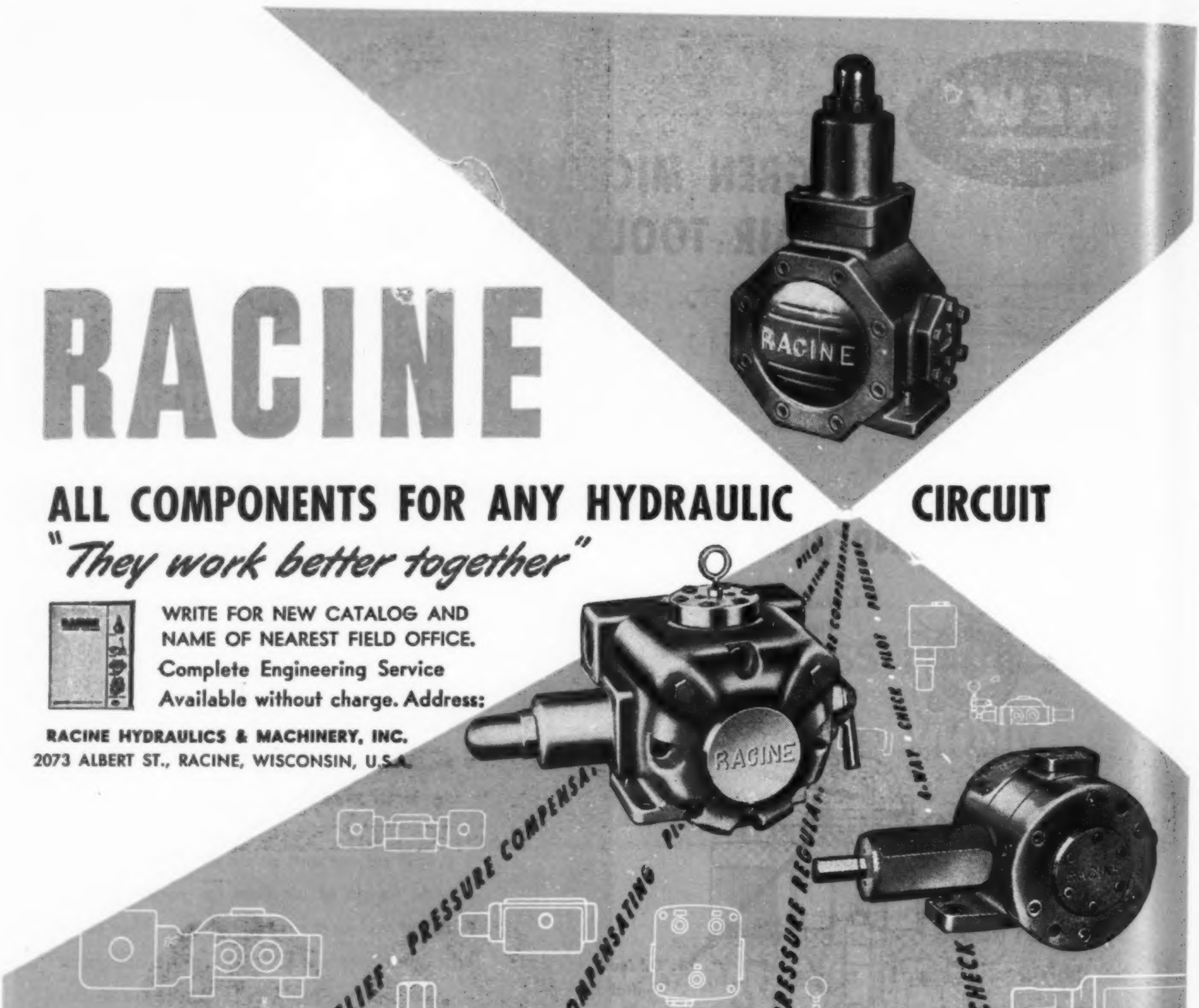
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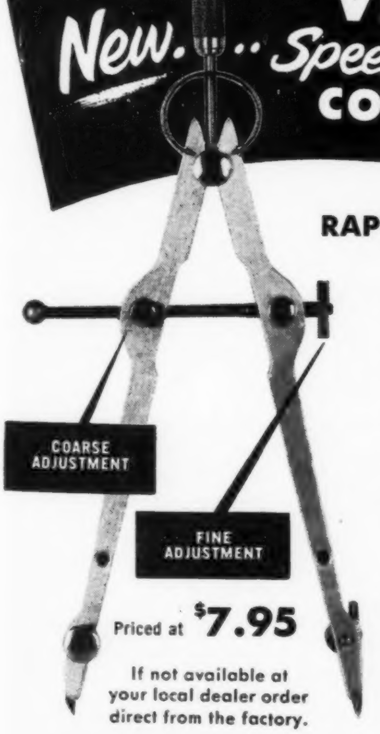

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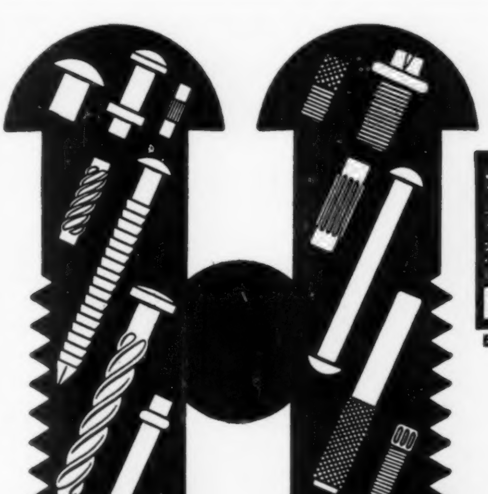

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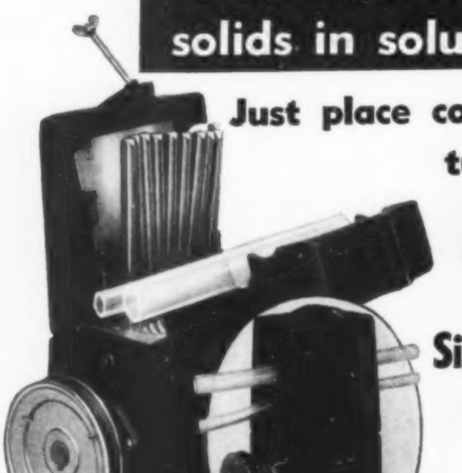

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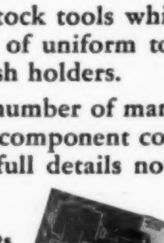

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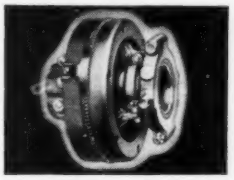

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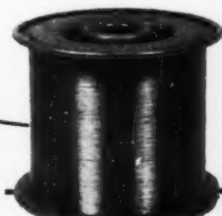

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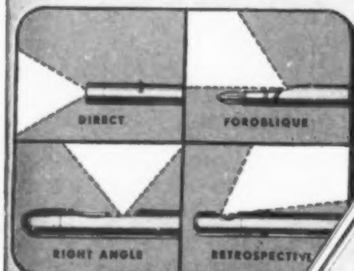

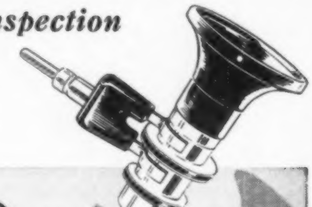

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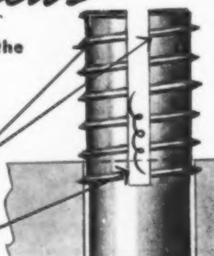
SETKO Self Tapping Set Screws

—in full range, including the smaller sizes
Save taps, save time, save on production cost!
2 Cutting Edges



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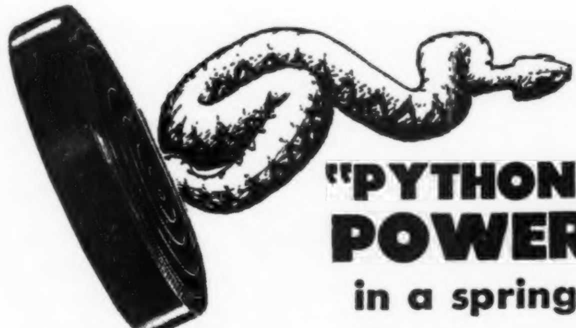

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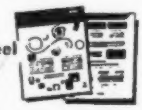

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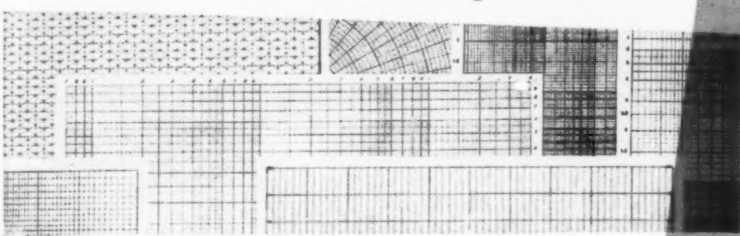

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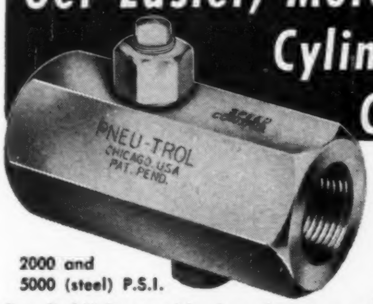

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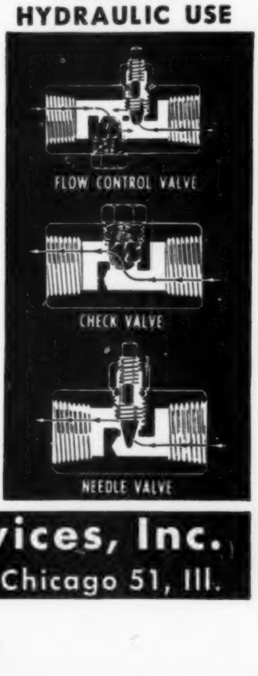

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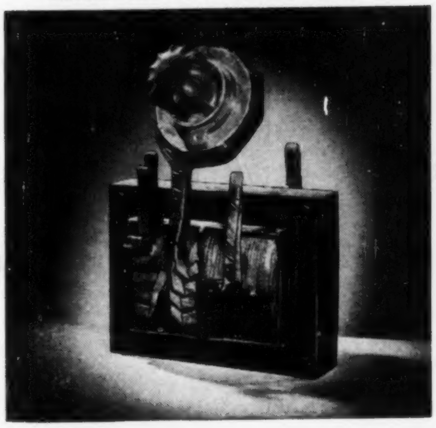

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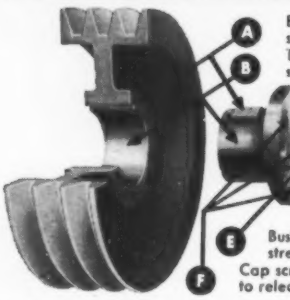

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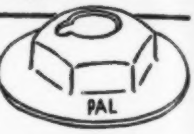

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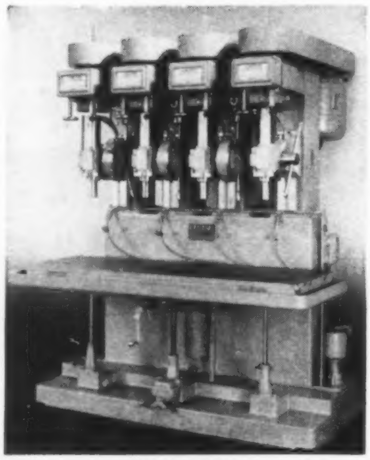

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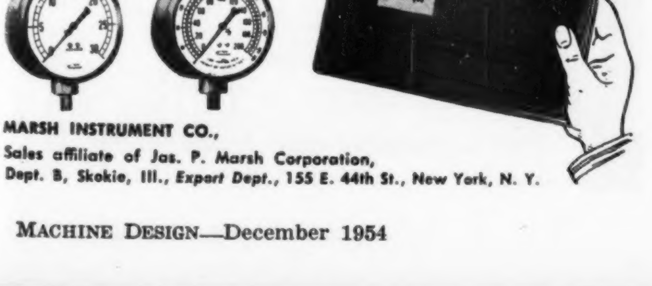

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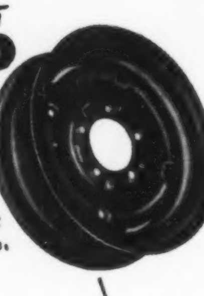

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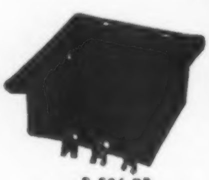

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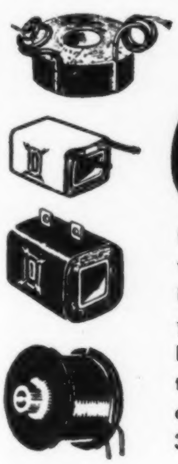

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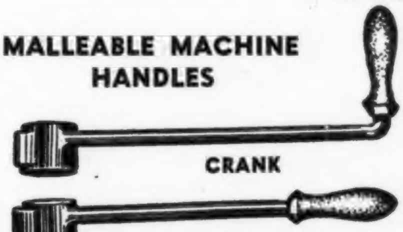

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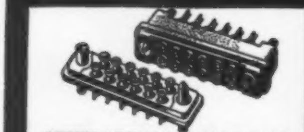
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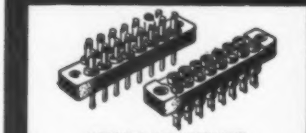
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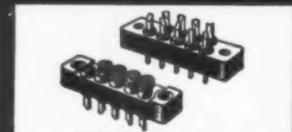
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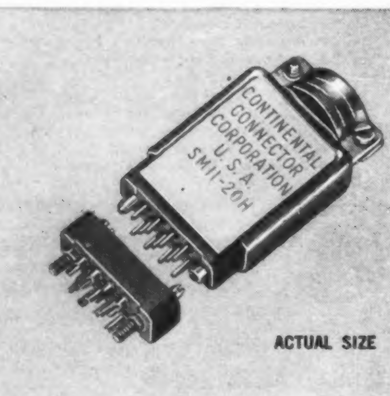
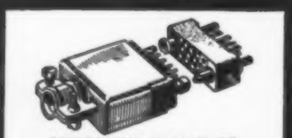


ACTUAL SIZE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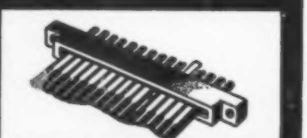
SERIES "SM-20" SUBMINIATURE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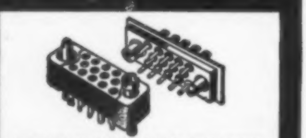
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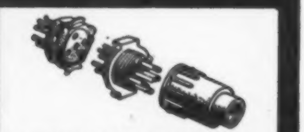
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Rectangular Series 'SM-20'
SUBMINIATURE CONNECTORS

When your miniaturized equipment needs subminiature connectors with the same durability and current carrying capacity of larger connectors, specify Continental Series SM-20. This series is available in 7, 11, 14, 20, 26 and 34 contacts, in a choice of Mineral filled Melamine, Plaskon reinforced (glass) Alkyd 440A or Diallyl Phthalate.

Polarization is unusually positive with a reversed guide pin and guide socket. Engagement and disengagement forces have been reduced without sacrificing millivolt drop. Voltage breakdown is 2700 at sea level, and 800 volts at 60,000 feet.

For illustrated technical literature, write Dept. MD Electronic Sales Division, DeJUR-Amsco Corporation, 45-01 Northern Blvd., Long Island City 1, N. Y.

Electronic Sales Division **DeJUR**

45-01 NORTHERN BLVD., LONG ISLAND CITY 1, N. Y.

Advertising Index

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B

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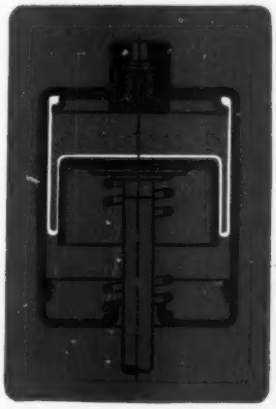
NEW

flangeless bead-type

Bellofram*
PISTON SEAL



. . . easy to apply

NEW CLASS 1 BELLOFRAM

The new solid head Class 1 Bellofram is a long stroke, deep convolution piston seal diaphragm developed for all pressure sealing applications. With the "O" ring bead-seal characteristic, it will operate efficiently at pressures up to 500 p.s.i. — or up to ten times the rating of ordinary diaphragm seals.

EASE OF APPLICATION SIMPLIFIES YOUR DESIGN PROBLEMS

Actuators using Class 1 Belloframs have longer stroke — are smaller, lighter, much easier to design and manufacture — do not require costly machining or precision alignment. Bellofram's *rolling action* (not sliding) minimizes friction losses. Dynamically stable Belloframs are made of modern fabrics and elastomers for high resistance to fatigue and extreme cycle life. The bead is not subject to operational stress, due to provable wall-friction coefficients and narrow semi-circular convolution of diaphragm under pressure.

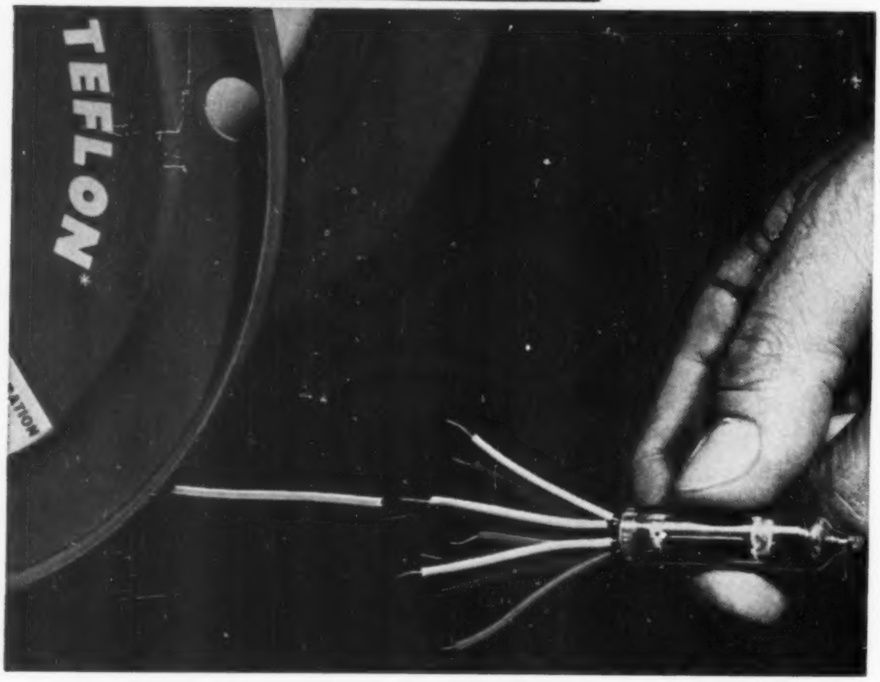
FLANGELESS BELLOFRAMS FOR YOUR APPLICATION

Put this major improvement in piston seal design to work for you now. Bellofram's unduplicated features include resistance to vibration and chemical action — operation over a wide temperature range — elimination of leakage — control of effective area to within 0.1% over complete working stroke. No lubrication needed — no maintenance except simple, infrequent replacement — accurate, economical operation where ordinary seals fail. Outline your application and submit a sketch to find out how a standard or custom-engineered Class 1 Bellofram can solve your pressure application problems. Your data considered confidential. Write today.

*Trade Mark

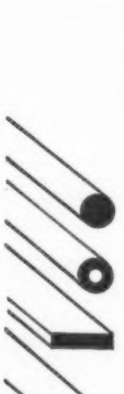
Bellofram
CORPORATION
144 MOODY ST., WALTHAM, MASS.

POLYPENCO® **TEFLON*** SHAPES



NEW! POLYPENCO® Teflon Spaghetti Tubing

- **The ultimate in insulation for wire conductors, leads, tube plugs, etc.**
- **Unaffected by heat from soldering operations**
- **Unaffected by repeated flexing**
- **Available in a choice of 7 different colors for color coding**



Now you can obtain the excellent dielectric properties of POLYPENCO Teflon in a spaghetti tubing that slips easily over AWG conductors . . . permits fast soldering of connections . . . and simplifies wiring and trouble-shooting in miniaturized UHF circuits. POLYPENCO Teflon Spaghetti Tubing also offers many desirable mechanical properties and resists weathering, chemicals, fungi, and high temperatures. Like other shapes of POLYPENCO Teflon, its quality is uniformly high in every shipment.

You can now get this new spaghetti tubing in natural, black, brown, red, green, blue and yellow colors. There's also a full range of internal diameters corresponding to American Wire Gauges 22 through 8. For convenient use, all POLYPENCO Teflon Spaghetti Tubing is supplied on reels in lengths of 100, 200, 500 or 1000 feet.

Write for price list and tubing samples

The POLYMER CORPORATION of Penna. • Reading, Penna.
In Canada: Polypenco, Inc., 2052 St. Catherine W., Montreal, P.Q.

POLYPENCO® TEFLON*
. . . nylon and other non-metallics

Warehouse stocks: Reading • Chicago • Los Angeles • Newton (Mass.) • Branford (Conn.)

**trademark for Du Pont tetrafluoroethylene resin*

Advertising Index

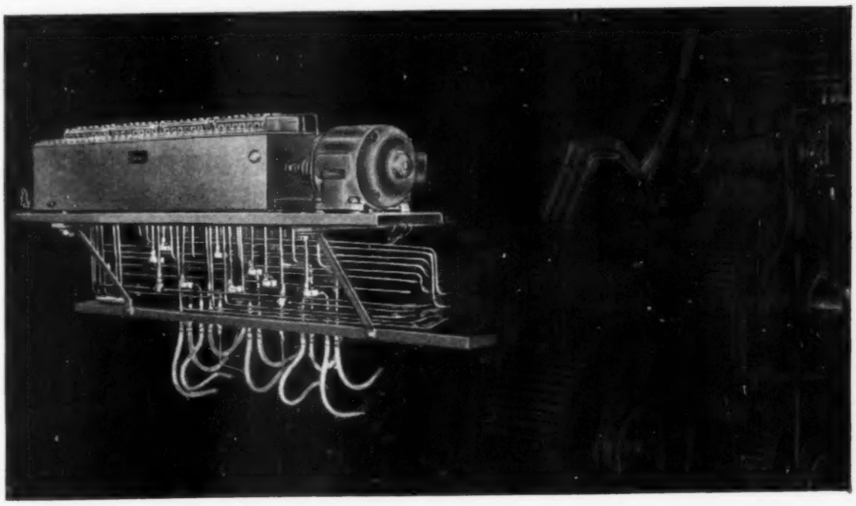
HOW BEST TO LUBRICATE

MANZEL *has the Answer!*

Pressure Application

Exact Amounts

Accurately Timed



✱ Manzel has the answer to simple or complex questions of dependable, care-free, automatic lubrication — the answer to putting exactly the right amount of lubricant at the right places and right times — the answer to lubrication against discharge pressures as high as 30,000 P. S. I. G. There is a Manzel Force Feed Lubricator to meet your specifications. And Manzel engineers are specialists at adapting them to your special needs. To answer any lubrication problem, write Manzel.

Manzel

DIVISION OF FRONTIER INDUSTRIES, Inc.

276 BABCOCK STREET, BUFFALO 10, NEW YORK

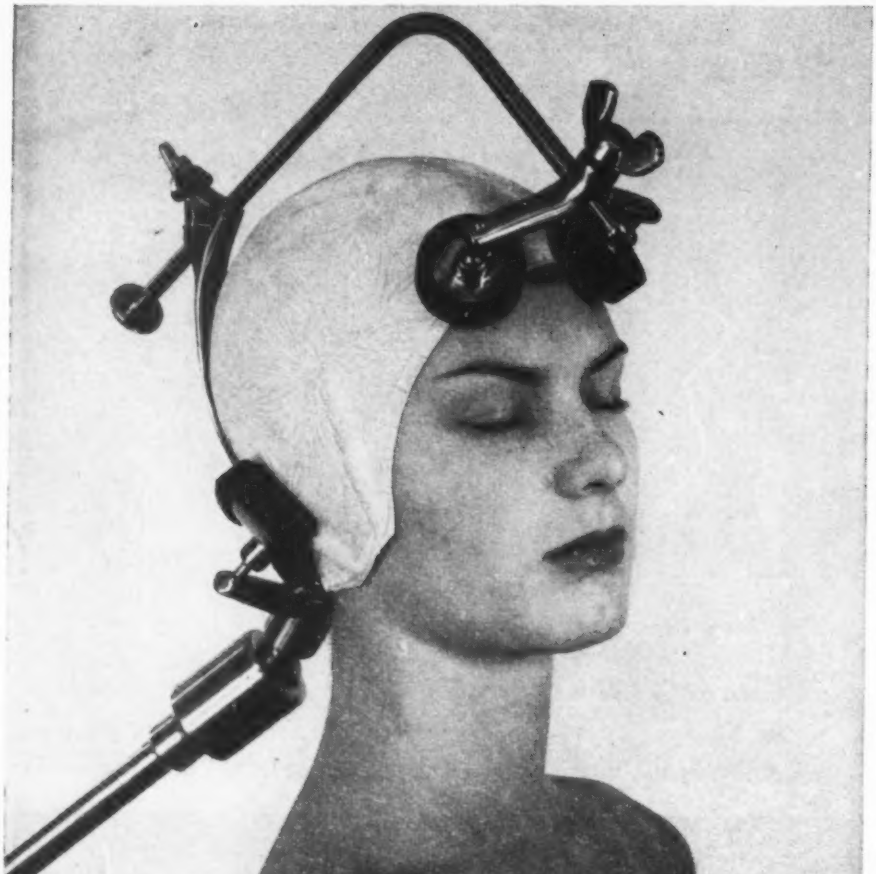


Photo courtesy American Sterilizer Co., Erie, Pa.

"Just What the Doctor Ordered"

New Super-Soft Rubber Pads Developed for Surgical Table Headrest

This surgical patient's head is in firm but gentle hands. The tight grip of the surgical table headrest shown above is now cushioned by super-soft (20 durometer) solid rubber pads. These pads are almost as soft as sponge but can be decontaminated and sterilized far more easily. Being made of neoprene, they are unaffected by oils, acids or decontaminating and sterilizing solutions. Furthermore, repeated sterilizing in live steam does not cause excessive hardening.

The neoprene compound specially developed for this purpose is 10 to 15 durometer points softer than normal commercial limits. For that reason, special care and skill must be taken in mixing and molding.

The successful development of this special purpose rubber part typifies the complete engineering and laboratory—as well as manufacturing—service offered by Continental.

Why not let Continental engineers consult with you in the planning or blueprint stage? Their specialized skill might help you get better rubber parts for your requirements.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these standard parts are shown in Continental's No. 100 Engineering Catalog. Send for a copy today. This catalog also is shown in Sweet's File for Product Designers.

Another achievement in **RUBBER** *engineered by* **CONTINENTAL**

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Advertising Index

P

R

S

—the ideal way to reinforce epoxy resin castings

The making of prototypes of many of the products which make up our modern living is being accomplished with the use of epoxy resin castings reinforced with MD Metal Powders.

Such compounds provide a new and unique method for making forming dies or molds, representing substantial savings. Tool-up time is greatly shortened—complicated assembly jigs are easily made by this method. The cost of such castings is considerably less than that of steel dies and time required for manufacture is materially reduced.

Satisfied users in many varied industries amply attest the superiority of MD Metal Powders for reinforcing such epoxy resin castings. Rigidly controlled uniformity of properties ideally suit them for this use.

While MD Aluminum, Copper and Iron Powders are largely being used for this purpose, other metal powders are also being tested. Write for MD Metal Powders Specification Sheet which gives full information on all powders available.

METAL POWDERS
METAL PIGMENTS
METAL ABRASIVES
Since 1916

METALS DISINTEGRATING COMPANY, INC.
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Plants:
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Berkeley, Calif.; Emeryville, Calif.

3239

SUBSIDIARY OF AMERICAN-MARIETTA COMPANY

WORLD'S LARGEST MANUFACTURER OF FINELY DIVIDED METALS

4500 per hour per machine!

You can't beat Revere Free-Cutting Brass for speed

The mounting nuts shown here are made by the Fischer Special Mfg. Co., Cincinnati 6, Ohio, out of Revere 9/16" hexagon Free-Cutting Brass Rod. Output is 4500 per hour per machine. This phenomenal rate of production is due to special adaptations of standard machines according to Fischer designs and the high quality of Revere Rod. These two important factors enable Fischer to compete price-wise with nuts produced by other methods.

Fischer nuts are chamfered and countersunk on both sides, have no burrs, and are made in sizes from 1/8" to 1-1/16", in various designs, such as hexagon, cap, thumb, spark plug terminal, lighting fixture. As a further indication of the efficiency of the Fischer operation it can be reported that during 1953 the company averaged 244,897 pieces per running hour.

If you machine brass, look into the virtues of Revere Free-Cutting Brass. See the nearest Revere Sales Office.

FISCHER WAFER or mounting nuts, made from Revere 9/16" Free-Cutting Brass Rod at a rate of 4500 per hour.

Revere Free-Cutting Brass Rod has speeded production for many firms, and saved them money.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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SEE "MEET THE PRESS" ON NBC TELEVISION, SUNDAYS

As a companion to its line of Type M Unibrake Motors with magnetic braking . . . Master now offers a line of Type D Unibrake Motors with dynamic braking.

HOW IT WORKS. Dynamic braking is obtained with a patented* unique, multi-polar brake winding superimposed on the stator winding of any Master single-phase or polyphase induction motor.

ADVANTAGES. Unibrake motors with dynamic braking are very compact, usually no larger than the standard motor. And since the dynamic brake has no moving parts, there is no wear . . . nothing to adjust . . . braking torque remains uniform.

INCREASE PRODUCTION. Don't waste valuable production time waiting for machinery to coast to a stop . . . get quick slow-down for machine tool spindles . . . quick turn-around time on many operations . . . speed up automatic cycling of machinery. And since Type D Unibrake Motors come to a rolling stop, they are particularly adaptable to equipment requiring gear shift between cycles.

SIZES. Now available up to 30 horsepower . . . larger ratings are being developed. Master Gearmotors and variable speed drives can also be supplied with Type D Unibrakes.

LITERATURE. For complete information write for Data 3810.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

Now

DYNAMIC BRAKING

for A-C motors

MASTER

UNIBRAKE MOTORS

* U. S. Patent 2,627,059

Completely new Bullard Cut Master V.T.L. Model 75 uses TIMKEN® bearings to insure extra load capacity, top precision

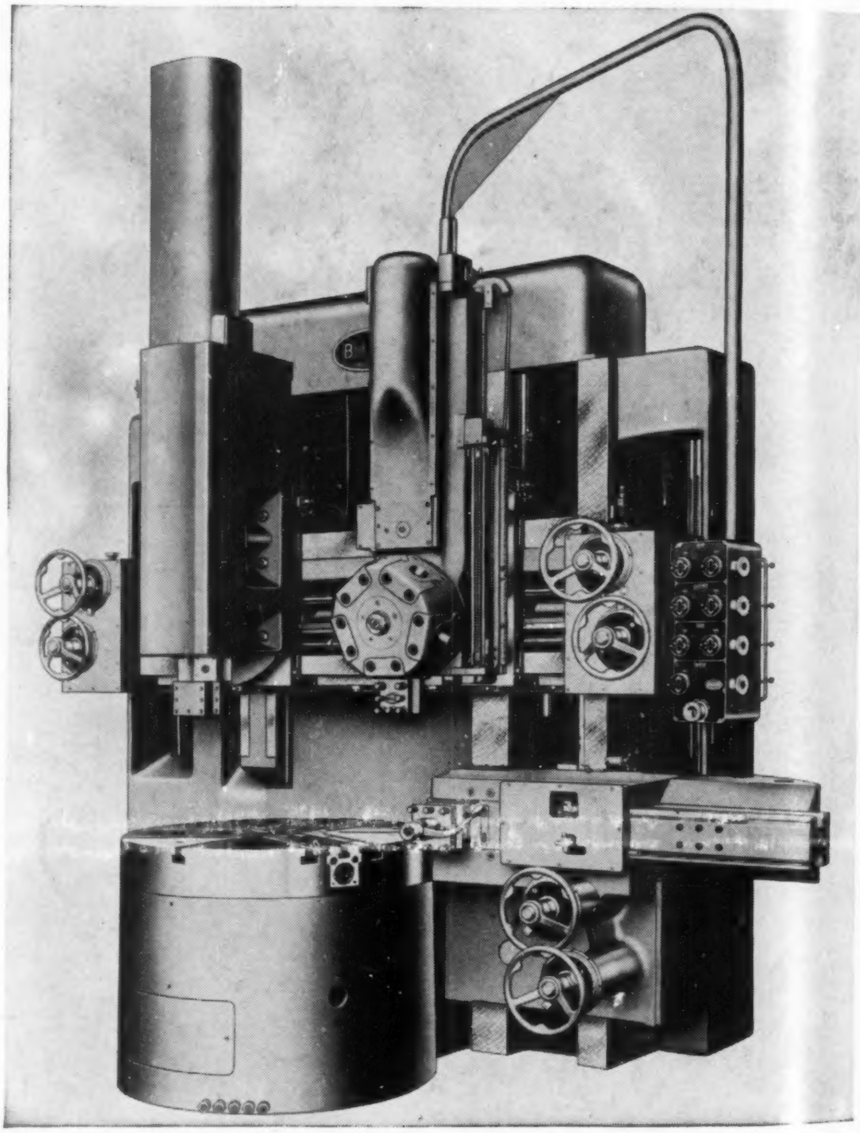
TO reduce power losses and provide highest efficiency at point of cutting, The Bullard Company engineers chose Timken® tapered roller bearings for the Bullard Cut Master Model 75, a completely new design of vertical turret lathes. Timken bearings are used in the table, headstock, feed and traverse mechanism, side, ram and turret head drives and other applications throughout the machine. They have been selected to meet the service requirements at each vital point with maximum efficiency. From 160 up to 196 Timken bearings are used according to the number and types of heads selected.

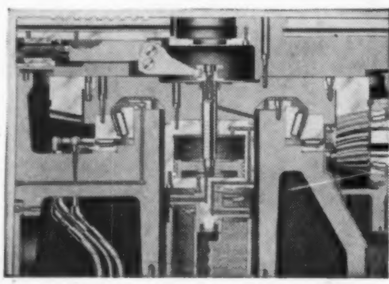
Timken bearings have extra load-carrying capacity that results from line contact between rollers and races. Tapered construction permits preloading, so deflection is kept to a minimum, and constant accuracy is maintained. Radial and thrust loads can be carried in any combination. Timken bearings are geometrically designed to roll true and precision manufactured to live up to their design. They hold shafts in rigid alignment, insure accurate gear mesh.

We take every step possible to make Timken bearings the best. We even make our own steel so we can control quality from beginning to end. We're the only U.S. bearing manufacturer that takes this extra step.

Make sure the machines you build or buy have bearings with the trade-mark "Timken". They're number one for value. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best





BULLARD design of table bearing construction uses Timken tapered roller bearings for long life, trouble-free performance

TIMKEN

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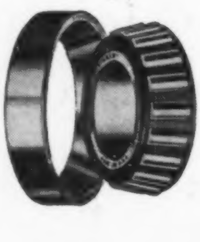
TAPERED ROLLER BEARINGS



NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER

BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION